16 MAY, 1914

Bulletin No. 181 May, 1902

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH

SILK CULTURE

By GERALD McCARTHY.

Publications sent to any address in North Carolina upon application.

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

UNDER THE CONTROL OF THE

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RALEIGH, N. C.

NOTE IN REGARD TO BULLETINS OF THE EXPERIMENT STATION AND THE DEPARTMENT OF AGRICULTURE.

The present popular Bulletin on "Silk Culture" was prepared by Mr. Gerald McCarthy, Biologist of the North Carolina Department of Agriculture. An article on the same subject by him was published in the November (1901) Bulletin of the Department of Agriculture, the interest in the subject and the demand for the publication within and without the State having been so great that the first publication has been entirely exhausted, and it has been thought advisable to present the present revised edition as a Station Bulletin.

The Experiment Station and the Department of Agriculture are carrying on their work so as to aid and supplement each others' efforts. It will likely in the future, as in the present case, be advisable, occasionally, to publish the writings of the workers in one institution in the Bulletin of the other, and the results of joint investigations will be presented by the institution in the best position at the time to put them out. The Bulletin of the Department of Agriculture is published monthly, while the Station will send out its Bulletin at such times as the materials in hand justify. *Both Bulletins will go in the future to the same mailing list.*

B. W. KILGORE,
Director.

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SILK CULTURE.

By GERALD McCARTHY, Biologist N. C. Department of Agriculture.

I.—History of Silk Culture.

Silk, the finest and most valuable of textile fibers, is the product of a small caterpillar, the larval form of a moth, *Sericaria* (*Bombyx*) *Mori*, a native of China.

The Latin name for silk is Serica, from the ancient name of Northern China (Sericaria), where silk was first produced.

Bombyx is from the Greek word bombos—sound, referring to the booming noise made by these insects.

The modern silk-worm is in the truest sense a domesticated animal. The species in the wild state seems to have ceased to exist ages ago. There is but a single species of the cultivated silk-worm, but this species has many varieties, some of which produce white silk, some green silk, and others yellow silk. There are also very numerous cultural races—each neighborhood in old silk-growing countries having a special race, usually called after the town or province. The domestication of the silk-worm took place in China about B. C. 2700. History relates that the Emperor Hoang-Ti, of that country, had a brisk and inventive wife, by name Si-ling Chi. The Empress had, it appears, a special talent for meddling with State affairs, and became such a public nuisance that she was at last advised by her husband, in words afterwards used by Shakespeare, to "Go spin, you jade, go spin." This excellent woman, taking her lord at his word, and not finding any spinable fiber handy, went into her garden and gathered a large number of worms she saw spinning cocoons on her mulberry trees. From the fiber produced by these worms she spun with the distaff silk thread. She next invented the silk reel and method of reeling the fiber, that, with a few modifications, is in use to this day. She then improved the old wool loom and fitted it for weaving silk. On this loom, with her own imperial hands, she wove the first piece of silk cloth the world ever saw. This cloth she presented to the Emperor, who thereupon issued an edict directing all gentlewomen in China to cultivate silk-worms and to pay divine honors to the Empress Si-Ling Chi. These things are so done in China even unto this day. From the days of Si-ling Chi, silk growing has been the special occupation of women and the younger members of the household. Silk culture is to this day a household industry over the whole of China, as well as in the neighboring countries. Until

the very recent introduction of cheap cottons, even the poorer classes in China were clad in silks of native production. From China, silk culture spread to India and Japan before the Christian era. Silken garments were first brought to Europe by the returning soldiers of Alexander, but the source of the fiber and the method of weaving it was not known in Europe till long after. The eggs of the silk-worm were first introduced into Europe at Constantinople during the reign of the Emperor Justinian, about the year 550 A. D. Two Nestorian monks, returning to Constantinople from China, brought samples of silken cloth, and seeds of the mulberry, which they presented to Justinian. The Emperor sent the monks back to procure eggs of the silk-worm, and to learn how to care for the worms and prepare the silk. The monks brought back with them a few hundred silk-worm eggs, hidden in a hollow bamboo staff. From these eggs are descended all the European races of silk-worms—which have brought prosperity to many nations for over 1400 years. Under the patronage of the Emperor and the instruction of the Nestorian monks, silk culture quickly took root in the Greek empire. The industry remained an imperial monopoly during the life of Justinian, but at his death became free. It soon spread through all Greece and adjacent regions. For several centuries Athens and Thebes were the chief centers of silk manufacturing in Europe.

Silk culture was first introduced into Italy at Palermo, A. D. 1146, by Greek prisoners of war, captured by Roger I, King of Naples. The Neapolitans attempted to keep the industry to themselves and monopolize the profits of the manufacture; but by the end of the thirteenth century silk-growing had been introduced into Lombardy, where it has ever since remained the chief agricultural staple.

The Saracens, by their conquests in the far East, became possessed of the secrets of silk weaving, but remained ignorant of the method of producing the fiber. They introduced the manufacture of silk into Spain and Portugal—bringing the raw material from Bagdad, to which mart silk fiber was sent from China and Persia.

Louis XI, of France, established a colony of Italian silk weavers near his Castle of Tours, but the attempt to domesticate the industry at that time failed. Subsequently silk-worms were brought from Lombardy into France in the seventeenth century, and the industry was encouraged by Henry IV, the reigning monarch. Olivier des Serres is called by Frenchmen the father of silk culture in France. It was finally established in the reign of Louis XIV, by the enlightened policy of the great French statesman, Jeane Baptiste Colbert.

Silk-worms were brought to Mexico by the monks who accompanied the army of Cortes in 1522. The greed of the Spaniard for gold, however, caused silk-growing to be soon abandoned in Spanish-America.

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James I, of England, in his famous "Counter-blast against Tobacco," recommended the Virginia colonists to cultivate silk-worms instead of the poisonous weed. He further encouraged the industry by offering premiums for colonial silk, and by publishing the following lines, more remarkable, perhaps, for good sense than poetry:

> "Where silk-worms and food do naturally abound
> A gallant trade in silk must sure be found.
> Virginia excels the world in both,
> Envy and malice can gainsay this truth."

But the superior profits of tobacco and the scarcity of domestic labor prevented the honest monarch's advice from bearing fruit in colonial Virginia.

Silk-worms were brought to Carolina and Georgia by the first settlers, and the industry quickly took root. For over thirty years these two colonies exported considerable quantities of raw silk to London. A silk-reeling mill was established at Savannah in 1750. In the year 1795 over $75,000 worth of raw silk was exported from Savannah.

The Huguenots who settled in the region about Charleston, S. C., in 1677, introduced silk culture, which soon became a fashionable and lucrative amusement of the ladies of Carolina. For nearly a century from $5,000 to $10,000 worth of silk was annually exported from Charleston, in addition to what was woven and consumed at home.

From and after 1785 silk yarn in skeins and hanks was for many years the common circulating medium and standard of value in Connecticut. In 1825 three counties in that State exported $35,000 worth of silk yarn, besides what they consumed at home. About 1830 the total annual production of silk in Connecticut exceeded in value $200,000.

In 1771 Franklin and other patriots induced the people of New Jersey and Pennsylvania to take up silk growing. The native red mulberry was in these experiments used exclusively as food, for which purpose it was found to be excellent, though a little later than the white mulberry. A good deal of reeled silk was exported to London from these colonies, and was there, notwithstanding the inexperience of the cultivators, rated equal to the best Italian silk.

The early French settlers of the Illinois country, now the State of Illinois, introduced silk culture, and about 1820 a great many mulberries were planted in the Western States. But the scarcity and high price of labor prevented silk growing from becoming established in that region.

In 1826 the United States Secretary of the Treasury, Richard Rush, caused to be prepared and published a Manual of Silk Growing, which was for many years the standard American authority. Silk growing soon became very popular in all the Atlantic coast

States. From 1838 to 1844, large nurseries of the Chinese mulberry —*Morus multicaulis*—were planted, and a speculative craze set in. Yearling trees of this variety were bought and sold for $2 to $4 each. In the winter of 1841 a very severe frost destroyed hundreds of thousands of these young trees, which were now found to be not hardy above Washington. The speculation in trees collapsed. Hundreds of silk growers who had paid fancy prices for their trees were ruined. Silk growing in the United States received a set-back from which it has never recovered.

The New England silk growers, instead of planting a hardier variety of mulberry and recovering their lost fortunes, now turned to silk weaving, using imported raw silk. During the Civil War there was a tariff duty of 60 per cent *ad valorem* on imported silk cloth, whereas the reeled silk or yarn came in free. This gave an enormous stimulus to American silk manufacturing. The census of 1900 shows in operation in the United States, 483 silk mills, having a total capital of over eighty-one million dollars; an annual output valued at over one hundred and seven million dollars; 65,000 hands are employed, and over twenty million dollars is paid for labor.

Practically no American-grown silk was put upon the market in the census year 1900. The cause of the substantial extinguishment of the silk-growing industry in America will be considered in the chapter dealing with the Future of the Industry. Suffice to say here, that the decline of the industry in America is not due to climatic causes, nor to the lack of available labor, nor the lack of worms or mulberries upon which to feed them.

The world's consumption of silk is rapidly increasing, and the price of the raw material, or cocoon silk, tends constantly upwards. The possibility of increase in the old world output is slight, as the limit has been reached. This offers additional inducements to the owners of millions of acres of suitable, but unoccupied land in the new world.

The world's production of raw silk in 1895 was as follows:

Italy	8,764,800 lbs.
China	11,310,200 lbs.
Japan	6,784,800 lbs.
India	4,378,000 lbs.
France	1,971,200 lbs.
Austria	585,200 lbs.
Spain	198,000 lbs.
Greece	38,600 lbs.
Persia and Central Asia	2,268,000 lbs.
Turkey and Caucassus	185,000 lbs.
World's output	36,483,800 lbs.

II.—Classification and Natural History of Silk-Producing Insects.

The mulberry silk-worm belongs to the Natural Order of Lepidoptera, the sub-family of moths, and to the tribe Bombycides.

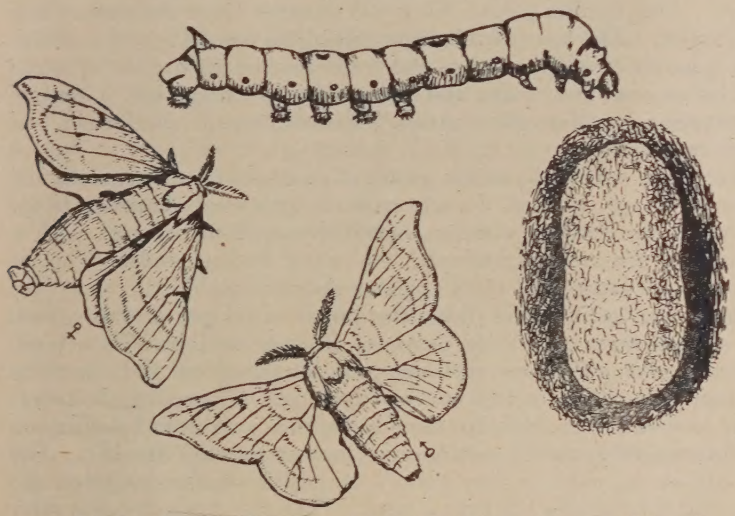

Fig. 1.—**Mulberry Silk-worm, Cocoon and Moths.** ♂ male. ♀ female

The Worm.—The silk-worm at birth weighs about one grain. Its color is normally brown at birth, but becomes darker after a few days. The body is composed of twelve separate rings or segments. Each segment, except the second, third and last, are marked on sides with two dark spots, which surround the spiracles or breathing pores. The worm has sixteen feet, of which the three pairs next to the head are true feet—the others are called "pro-legs." They are fleshy and soft like the body. On top of the next to the last segment there is a short blunt horn. The head of the worm is formed of two sealy, spherical plates, separated by a triangle. In the front part of the head are six or seven black spots. These are the eyes. Below the eyes is the mouth, armed with two toothed jaws, which move in a horizontal direction when chewing. The silk spinneretts are two in number and situated on the middle of the lower lip. The silk reservoir is within the body and extends the entire length of the body, being much doubled and twisted, so that when straightened it is over one and one-half feet long. The silk within the reservoir resembles thick mucilage.

The common annual silk-worm molts or casts its skin five times, each new skin being lighter colored than the last. The last cast is

made within the completed cocoon. The casting of the skin permits the worm to grow or expand. Molting is a very laborious operation and none but healthy worms can survive it. When a worm fails to cast the skin at the proper time it soon after dies.

The Pupa.—The pupa or chrysalis stage is passed within the cocoon. During this period the insect changes from the worm form to the moth. The body of the pupa within the cocoon is covered with a hard, horny envelope, within which the former organs of the worm melt into a semi-fluid mass, and then under the attraction of centers of attraction, or "formative plates," the new organs are formed out of the pasty matter.

The Moth.—The silk-worm moth is about two inches across the outspread wings, whitish, densely covered with wooly hairs on body. The wings are four in number, nearly transparent, covered with a whitish powder and marked with two wavy brown bands. The female is much larger and more sluggish than the male.

The moth, as it comes from the pupal envelope, is full grown and as complete in all its parts as it ever will be. The moth of the common silk-worm possesses only an imperfect and functionally useless mouth. It does not eat anything. The mouth, however, serves to moisten and dissolve the silk fibers at one end of the cocoon and through this part the moth pushes its way into the free air. The free life of the moth is very short—usually for males not over two days, and for females not over a week. The two sexes are generally equal in numbers.

The Cocoon.—After the silk-worm becomes full grown it ceases to eat, diminishes in size, ejects the greater part of the contents of its alimentary tract, and seeks a retired spot among branches of trees to spin its cocoon. Having found a suitable place it first throws out numerous loose threads, forming the so-called "floss silk." Within this loose envelope it then forms the tough body of the cocoon by laying down silk threads in regular figure of eight loops. The inner side of the cocoon is lastly covered with a water and air-tight cement. About 19 per cent of the total weight of the fresh cocoon is silk. The rest is weight of chrysalis and castings. The construction of the cocoon requires about two days of unintermittent labor. The form and color of the cocoon differs considerably with different races, but with the yellow Italian races it is yellowish, oval, sometimes constricted in center, about one inch long and one-half inch in diameter. About 300 weigh one pound. Within the completed cocoon the worm takes two days to cast its skin for the last time and enter the pupal condition. The total period from the hatching of the worm to the beginning of the pupal stage is from 28 to 32 days. The pupal stage lasts from 12 to 20 days, depending upon the temperature of the surrounding air. After the moths have emerged, they dry their wings,

eject a quantity of reddish liquid and flutter about until the sexes pair. Though the wings of these moths seem perfectly adapted for flight, they never attempt to fly. Copulation continues for five or six hours; the male soon after dies. The female at once begins to deposit her eggs and continues until she has laid 300 to 400. She dies soon after.

The Egg.—The egg of the common silk-worm is about the size of a mustard seed, yellowish at first, but in a few days becoming slate-colored. The eggs of the single brooded silk-worm can not be made to hatch until after several months and the seasonal variation of temperature proper to a temperate Northern climate. There are also bi-voltin or double brooded varieties, which, however, are not suitable for culture in temperate climates.

Next in value to the mulberry silk-worm we must rank the Indian species, of which there are three of prime importance. All these are "polyvoltin" or many brooded. They feed upon plants other than the mulberry. The fiber produced by the Indian worms is much coarser and stronger than that produced by the mulberry worm. The cultivation of the Indian worms need not in any way interfere with that of the common worm, since the two classes of silk will mutually complement each other, and will serve to produce mixed fabrics better for many uses than either can produce alone, thus greatly extending the usefulness of silk fiber.

The Tusser Worm—Antherea mylitta.

Fig. 2.—**Indian Tusser Worm and Cocoon.**

The Tusser worm belongs to the moths, and to the tribe of Attacides. This family differs from the Bombycides in forming an open cocoon, though the Tusser itself being the connecting link forms a fairly close cocoon.

The Tusser is a native of Assam, and has there been cultivated for time out of mind. The species is usually fed on trees and bushes out of doors, but may be fed wholly indoors like the mulberry worm. It is two-brooded and gives two harvests of cocoons annually. The first brood of worms hatch about June 1st from eggs kept indoors since the preceding fall. The eggs require nine days to incubate, and forty days to reach maturity. The worms molt five times. The pupal stage continues for 21 days. The

first harvest of cocoons is ready about August 1st. The second harvest is ready about October 1st.

The Tusser worm when full grown is about seven inches long. The cocoon is oval, two and one-half inches long and one and one-fourth inch in diameter. The fiber is buff-colored, very coarse and strong. The cocoon not being firmly closed, the fiber is difficult to unwind, but special machinery has been invented in England for this purpose. Instead of pure water a 3 per cent solution of potash is used to macerate the cocoons.

The Tusser feeds chiefly upon shrubs of the Buckthorn family. Its favorite food is the shrub *Zizyphus jujuba*, which is with us a tender greenhouse plant, but hardy in Florida. Another species, *Zizyphus vulgaris*, is perfectly hardy south of Philadelphia, and makes an excellent hedge plant. The crape Myrtle, *Lagerstroemia Indica*, is another favorite food of this worm. This is entirely hardy south of New York. The leguminous plants, *Cassia*, sp., are eaten by this worm, as is also the castor-oil plant.

The Tusser worm is likely to be of great value in the South Atlantic, Gulf and Mississippi Valley States.

The Muga Worm—Antherea Assama.

Fig. 3.—**Indian Muga Worm, Cocoon and Moth.**

The Muga worm is a sister species to the Tusser, and is a native of the same region. The Muga worm produces five broods and five harvests of cocoons annually. Each generation molts four times, feeds about thirty days, and passes fifteen days in the pupal stage. The worm when full grown is about five inches long, green, with red warts and a yellowish stripe along each side. The cocoon is about three inches long and one inch in diameter. The fiber is yellow or white. It is less coarse, reels more easily, and is more valuable than the Tusser silk. Formerly the royal robes of the kings of Assam were made of this silk.

The Muga worm feeds upon the same plants as the Tusser, and can be reared rather more easily, and in the same region. In fact, it can be profitably reared wherever the castor-oil plant thrives.

The Eri Worm—Attacus ricini.

The Eri worm is closely related to the two last-described species. It is many brooded, and usually gives five harvests of cocoons annually. The eggs incubate in 10 days; the worms feed for about 30 days, molting four times. The pupal stage lasts about 15 days. The full-grown worm is about 3 1-2 inches long, light yellow, with shades of green and white. The cocoon is oval, 1 1-2 by 1 inch. The fiber

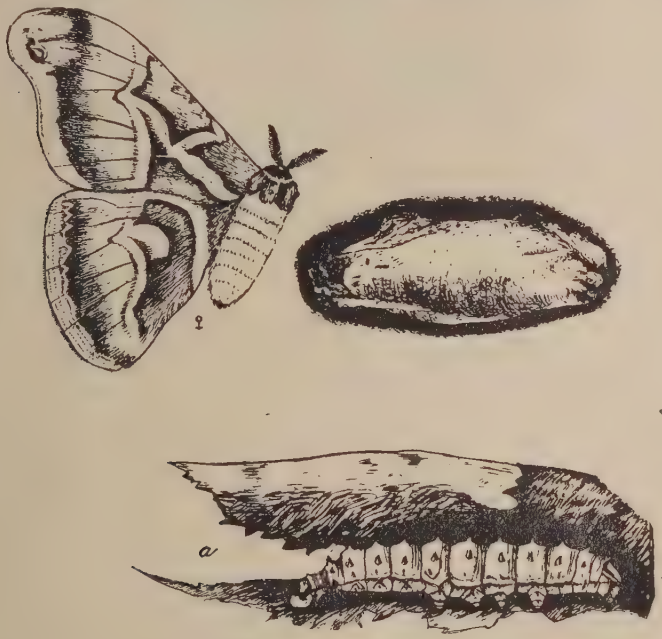

Fig. 4.—**Indian Eri Worm, Cocoon and Moth.**

is white. The silk is rather coarse, and must be combed and spun like linen or long wools. It makes a fabric practically indestructible by wear.

The chief food plant of this worm is the castor-oil plant. There is a great demand for the cocoons of this worm in England, where special machinery has been invented for working it. The cocoons bring about 75 cents per pound.

The Eri worm offers exceptional promise for the hot alluvial soils of the Southern and Western States where the castor-oil plant flourishes.

All three of the last-named worms are more robust and less troublesome to grow than is the mulberry worm. Being many brooded, they will afford work for at least nine months in the year. The castor-oil

and other plants upon which these worms feed can be so grown as to supply fresh leaves at all times when the worms require them. In rearing these Indian worms the temperatures advised for the mulberry worm must be increased about twelve degrees in every case. It must also be borne in mind that in their native home these worms are subject to almost daily deluges of rain, therefore, when reared artificially they should be daily sprinkled with water heated to about 90 degrees F., and the air of rearing room must be kept very moist.

The Japanese Tusser Worm—Antherea yama-yama.

This is another sister of the Indian Tusser worm. It is single-brooded, and feeds only upon the oak. The silk is coarse and very strong, white or green. Each cocoon gives about 1,000 yards of fiber. This worm is very hardy, and will thrive wherever the oak does, but it would be rather a difficult matter to gather oak leaves for feeding. The attempt to cultivate this worm in the United States is not recommended. It can not prove as profitable as the same labor when applied to the care of Indian worms.

The Chinese Tusser Worm—Antherea Pernyi.

This is another sister of the Indian Tusser. It feeds upon the oak and is very similar to the Japanese worm, but produces two broods and two harvests annually. The worm in China is entirely wild, the spontaneously-produced cocoons being gathered from the woods. The silk of this worm produces the fabric known as "pongee" silk in the market.

The Madagascar Silk-Worm—Brocera Madagascarensis.

This is a very close relative of the mulberry silk-worm, and in its native country feeds upon the mulberry. It is, however, far inferior to the common mulberry worm, and, therefore, merits no further attention from us.

The American Silk-Worms—Telea, Samia and Tropia.

The three genera above named are native, wild, silk-producing worms, not very closely related to the true mulberry worm. They all produce large cocoons, of coarse and poor silk. These insects feed upon our most valuable fruit and shade trees. No attempt should be made to propagate the worms artificially, as they are liable to become destructive pests.

Theophilia and *Rondetia* are two wild Chinese species of silk-worms equally as valueless as the last-named. These worms are mentioned here only to warn silk growers to beware of them, and, in fact, of all wild silk-worms, which, like the Gypsy moth, when introduced may cause wide-spread disaster.

III.—The Food of Silk-Worms.

The natural and aboriginal food of the mulberry silk-worm is the leaves of the white mulberry—*Morus alba*, and its varieties. The red and black mulberries are good, but less valuable. The so-called paper, or Otaheite mulberry, of the Southern States, is not a true mulberry, and is of little value as food for silk-worms, though they eat it well during their last age. The osage orange—*Maclura auriantica*—a tree very closely related to the mulberry, makes excellent food, but is too succulent and is liable to cause disease.

The leaves of the garden lettuce and garden scorzonera are often used as food for silk-worms. They do very well for a few days, but the worms do not thrive when fed exclusively upon these plants. The white mulberry and its varieties must always remain the standard food plant for silk-worms. Silk culture can never be made profitable where these trees do not thrive.

Botanists classify the American and European mulberries into three species, as follows:

Morus alba—Chinese or white mulberry.

Morus nigra—English or black mulberry.

Morus rubra—American or red mulberry.

In regard to the latter two species, it is sufficient to say that they are inferior to the Chinese or white species, but may be used where they abound.

The white mulberry, like all long-cultivated trees, has varied into many distinct forms, which are usually given special names.

The following varieties are considered by competent authorities to be good, and worthy of varietal names:

Morus alba, var. multicaulis. Synonyms—tartarica, indica and latifolia.

Morus alba, var. Moretti. Synonym—macrophylla.

Morus alba, var. Japonica.

Morus alba, var. Constantinopolitana.

Morus alba, var. Downingi.

1. *Morus alba.*—The white mulberry. A small tree, growing about forty feet high. Leaves ovate, thin, smooth, glossy on both sides. Acute at apex, rounded at base, toothed or lobed on edges. Leaf stalks slender. Flowers white or pinkish, in unisexual, drooping spikes, appearing in May. Fruit white or red, edible, but insipid, ripe in July. Hardy everywhere from Ontario to the Gulf, and from the Atlantic to Pacific.

2. *Morus alba. var. multicaulis.*—The Chinese mulberry. This is a smaller tree, but resembles the above species except that it has larger and thinner leaves and black fruit. It is very fine food for silk-worms, but is not hardy north of the Potomac River. It is very com-

mon in central North Carolina, dating from the speculative craze of 1840. It suckers so badly it is a nuisance in a yard.

3. *Morus alba. var. Moretti.*—Italian, or Dandelo, mulberry. This is a shrub, even less hardy than the preceding, but is excellent food for the silk-worm. It has very large leaves. The Moretti mulberry is much planted in Italy and France, where it is usually grown in form of a hedge. It is hardy in North Carolina.

4. *Morus alba. var. Downingi.*—Downing's Ever-bearing mulberry. This is a seedling of multicaulis grown by the eminent horticulturist, Charles Downing. It bears for six or eight weeks of summer edible fruit of the finest quality. As food for silk-worms it is equal to any. It makes a very beautiful shade-tree, resembling the Chinese variety. It is hardy as far north as Long Island. Does not sucker. This is the mulberry *par excellence* for the Southern silk grower. It does best planted in orchards about 20 by 20 feet. Of the other varieties of white mulberry little is known, but they are probably inferior to those herein described.

Fig 5.—**The Downing Mulberry.**

5. *Maclura auriantica.*—The osage orange. The osage orange is a close relative of the mulberry. It is extensively grown in the South and West as a hedge plant. It bears large and sharp thorns. This tree is rarely grown as a standard, but when it is, it makes a beautiful tree of 30 feet height, with a spread of boughs of 50 to 60 feet. It is hardy as far north as New York City. Makes good food for silk-worms, but rather succulent and in inexperienced hands is liable to cause indigestion. Not as valuable as the mulberry, but as the tree is hardier and the leaves start two weeks before those of the white mulberry, it is valuable for early feeding. It will be well to have a few trees or a short hedge of this plant on every silk-producing farm. But

no one should attempt to feed silk-worms exclusively upon the osage orange.

6. *Scorzonera hispanica.*—The oyster plant. This is a hardy perennial herb of the composite or daisy family. It is commonly grown in vegetable gardens for its root, which in shape resembles a parsnip, but tastes like a very insipid oyster. It seeds abundantly, and when cultivated it is usually sown afresh every two years. It is perfectly hardy everywhere in the United States. This plant has recently been extravagantly praised by Russian scientists as food for the silk-worm. It is claimed that the silk produced by worm fed on this plant is equal to the best, and that there is less disease among the worms and less loss by stained cocoons than when the worms are fed upon mulberry leaves. Scorzonera can be grown as an annual in any climate that produces wheat. We do not recommend scorzonera as a substitute for the mulberry, but it will be well for all silk-growers to have a small bed of this plant for early use when the mulberry may be retarded or nipped by late frosts. The leaves are cut and fed in same way as those of mulberry.

7. *Lactuca sativa.*—The garden lettuce. Lettuce leaves have often been used as a temporary food-plant for silk-worms. Any variety of lettuce will do, but those having hard and less succulent leaves should be preferred.

8. *Cannabis sativa.*—Cultivated hemp. The hemp plant is a close relative of the mulberry, and the worms will eat it, but as it is much later than the mulberry, it has little practical value in this connection.

9. *Ricinus communis.*—Castor-oil plant. As food for the Indian silk-worms, described in this Bulletin, the castor-oil plant will be found by far the most profitable and practicable plant. In the United States this plant is a tender annual, but thrives luxuriantly on rich moist soils in the Southern and Western States. The plant is cultivated mainly for its oily seeds, from which over 600,000 gallons of oil is annually made in the Western States. The cultivation is similar to that of Indian corn. When grown mainly for silk-worm food, by taking only half the leaves, it is possible to secure a crop of oil-bearing seed as well as leaves, thus getting double toll.

10. *Cassia occidentalis and C. Marylandica.*—The Cassias belong to the legumine family of plants. The species named are both very common in the Southern States, and both are perennials. These will probably be found well suited for feeding the Indian worms.

11. *Zizyphus vulgaris.*—The Zizyphus plant is a perennial shrub belonging to the Buckthorn family. It makes an excellent hedge-fence, and is quite hardy everywhere in North Carolina. Zizyphus jujuba, the Jujube plant of Asia, is the species preferred by Indian silk-worms, but this is not hardy in the United States, except where the orange thrives.

12. *Lagerstroemia Indica.*—The Crape Myrtle. This is a shrub or small tree very common, and hardy everywhere in the Carolinas. It is a favorite food with many of the Indian worms, and will be found very valuable in the cultivation of these worms. It is best grown as a hedge plant.

For the sandhill and long-leaf pine regions the three last-named plants are likely to prove most profitable, as they all thrive upon dry, sandy soils, when properly fertilized. The castor-oil plant thrives only on very rich, moist soils, such as river bottoms.

The osage orange and the Moretti mulberry should always be grown in hedge form. The Downing, multicaulis and white mulberries may be grown as low-branching shrubs.

For a hedge plant the rooted cuttings or rooted seedlings in rows two feet apart in the row. Usually the hedge is used as a fence around a plot of ground, but it may be grown in rows 15 feet apart. For the tree or shrub form, plant 15 by 15 feet, and make the plants branch from the ground. Prune back severely every second year. The leaves should not be gathered before the plants are three years old, and after that gather only on alternate years, or at least give one year's rest in three. The ground should be kept cultivated from early spring until July, then sow the middle of row in cow-peas. Chickens or hogs may be allowed to run in a mulberry orchard, as both are very fond of the fruit. Poultry and silk-worms go well together, and make a good, all-the-year-round business.

All the mulberries except Downing are easily propagated by cuttings of mature wood, by root cuttings and sprouts, by grafting, budding and by seed. Seedlings of the common white mulberry are considered the best, especially for hedges. Nurserymen sell one-year seedlings for about $6.00 per 1,000. The seed should be soaked 48 hours before sowing, then sown about two inches apart in drills 12 inches apart. Cover about half inch deep and keep moist until the seed has germinated. The seed take 15 to 20 days to come up. The young seedlings must be well cultivated and the soil kept mellow. Pinch off all lateral twigs to force the growth into the main stem. If the ground is sufficiently rich, the seedlings should be fit to transplant the succeeding fall or spring. In transplanting use a dibble and set the plants a little deeper than they stood in seed-bed.

In propagating by sprouts, first cut back the parent tree very severely and loosen up the ground about it. Sprouts will come up all around. Fertilize the ground generously and let all grow for one year. Then carefully dig—not pull—up the sprouts and transplant to the permanent situation. This is a rapid and satisfactory way of securing a plantation.

To propagate by cuttings, take 12-inch cuttings of the two-year old wood. Plant thickly in rich soil just deep enough to cover all but the

two uppermost buds. Cultivate cleanly and water in dry weather. Usually 50 per cent of the cuttings will root and may be transplanted when one year old.

Layers are made by bending down branches and covering all but a foot or so of the tip with soil.

If a nick is made every four inches of the part covered the branch will root at that point, and in this way a large number of rooted plants can be obtained from one branch.

Grafting or budding the mulberry is the least satisfactory way of propagating it. As a rule it will not pay anyone not a professional to attempt to graft the mulberry.

The pipe-stem or ring graft must be employed. Budding is even less satisfactory, as few of the buds live. Budding is done in the same manner as with the peach.

The mulberry is naturally long-lived, and is subject to few pests. Rotting of the trunk following wounds is the most frequent trouble. A good and cheap dressing for such wounds is the once celebrated "Forsyth's Dressing," made as follows:

Old cow manure, free from litter	16 parts.
Old mortar, finely pounded	8 parts.
Wood ashes	8 parts.
Clean sand	1 part.

Mix dry, and pass through a sieve. Wet with water enough to make a stiff batter. Smear this dressing upon the wound and allow to dry, then rub smooth with a burnt bone.

The best fertilizer for mulberry trees kept for silk-worm food is a mixture of one-half kainit, one-quarter acid phosphate, and one-quarter nitrate of soda. Where fowls are kept in the orchard little or no nitrate will be needed. The double sulphate of potash and magnesia may be substituted for kainit. A mixture of 200 pounds of muriate of potash, 600 pounds of acid phosphate, and one ton of stable manure makes a suitable fertilizer. But stable manure alone does not contain the necessary plant food to make the best quality of silk-worm food. It tends to produce a too succulent growth, which is liable to cause disease in the worms, especially Flacherie. Potash tends to make solid, starchy and nutritious leaves, and is, therefore, a necessary part of a good fertilizer for the mulberry. Acid phosphate tends towards rapid maturity of the leaves, which is also desirable.

IV.—Rearing the Mulberry Silk-Worm.

There is but one species of the cultivated silk-worm, but there are many varieties of this species named after the color of the cocoons, and a still greater number of cultural races. Every important silk-

growing district has a special race, which is believed by the local inhabitants to be superior to all others. Among the best-known of these races may be specified the Umbrian, Ascola and Marches races of Italy, and the Cevennes, Var and Pyrenees races of France. The Italian races are more prolific, but less hardy than the French. Italian raw silk is admitted to be superior to the French, and vastly better than the Chinese.

In describing the life history of the silk-worm, we will begin with the egg, in which form a start is usually made in this business. The eggs can be bought in the market. They cost about $2.50 an ounce. The eggs of the silk-worm are yellowish, and about the size of a mustard seed. During incubation they change color, becoming violet or green. The common unit used in speaking of silk-worm eggs is the ounce. The standard ounce is equivalent to 25 grammes, and contains about 40,000 eggs. The mother moth lays between 300 and 400 eggs, so that it requires 100 females to produce one ounce of eggs. But as the insects mate but once, there must be an equal number of males in order to have fertile and viable eggs.

The progeny of one lot of eggs placed to incubate at same time is called an "education." For convenience and to save time, it is very necessary that all the eggs of one batch or "education" shall be of equal vigor and general constitution, in order that they may go through their metamorphosis and changes at the same time. To insure this, eggs from different sources should not be mixed together.

Though the eggs of the common mulberry silk-moth are produced in early summer—usually June—they will not hatch until they have passed through the regular seasonal variations of temperature, nor with ordinary treatment can they be made to hatch until after six months. After March 1st, however, a warm spell of weather is liable to start the dormant life process long before the mulberry or other food is available. To prevent too early hatching, it is the custom in Italy to send the worms from the lowlands, where most of the silk is grown, into the cold valleys of the Alps during the month of January. Here the worms are subjected to a temperature usually many degrees below the freezing point—often 10 degrees F. The same result is effected by putting the eggs into a dry refrigerator for about a week. The period of severe cold is thought to harden the worms and make them less liable to disease. So long as they are kept dry, no ordinary amount of cold will injure the eggs. But the more severe the cold, the slower the eggs are to hatch when put to incubate. On no account should the eggs be kept at or near a uniform temperature during the entire dormant period. The silk-worm is not a tropical insect. It is habituated to climatical variations of temperature, and when these fail the eggs spoil. The eggs must not at any time be exposed to strong or direct sunlight. The period of incubation is about six days, at a

temperature of about 73 degrees F. When the eggs are set to incubate, the temperature must be gradually raised, beginning with the natural temperature, which is, in the first week of April, about 48 degrees F. Increase slowly to 55 degrees F. during first 6 days. Hold it so for 4 days, then increase one degree per day until it reaches 67 degrees F. Hold it so for 2 days. Then increase one degree per day until it reaches 72.5 degrees F. to 73 degrees F., and hold it so until eggs hatch.

The eggs will usually hatch in six days after the temperature of 72.5 degrees F. is reached. The whole period from first raising the temperature above the temperature of the season to the hatching should be about 20 days. Therefore, in North Carolina the start should be made about April 10th, so as to bring the worms by May 1st. It is very desirable to have the worms out as early as food can be had for them in order to escape the heat of June during the spinning-up process. The silk-worm is unable to stand much heat.

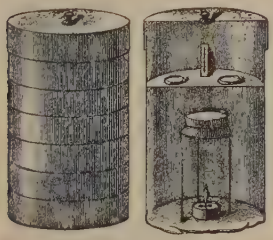

Fig. 6.—Silk-worm Incubator.

An ordinary chicken incubator may be used for hatching the eggs, or a small room which can be well ventilated may serve; a small tile stove may be used to heat the room. The floor of room must be frequently sprinkled in order to keep the air moist. In the incubator, use a wet sponge, as in hatching fowls' eggs. A good incubator in which the temperature is regulated automatically is the safest and best way to hatch silk-worm eggs.

Fig. 6 shows a form of silk-worm incubator commonly used. Any tinsmith can make one of these. The lower part containing the lamp must be well ventilated so as to remove all gases. The eggs usually come to hand glued by the mother insect to squares of cloth—each square having about 300 eggs (see Fig 10), but some breeders scrape them off the cloths. To incubate, the cloths or saucers are simply laid upon shelves, or better, on a lattice frame which allows the air to circulate freely on all sides. While the eggs are incubating, the rearing-room must be carefully and thoroughly cleaned and disinfected. First, scrub all the woodwork with soap and hot water. After it has dried, fumigate with burning sulphur, using three pounds of roll brimstone to each 1,000 cubic feet. A room 10 by 10 feet contains 1,000 cubic feet. To fumigate, break the sulphur into small pieces. Place in a heavy iron pan. Float this pan in a tub of water in the room. Throw upon the sulphur a shovel of hot coals and quickly vacate the room. The room should have been made air-tight. Let stay closed 12 hours. After fumigating, the walls should be whitewashed. The most scrupulous cleanliness must be maintained during the entire "education" of the worms.

The question of space is one of very great importance in raising silk-worms. The worms are very small at first, but they increase rapidly, and the space they occupy must be extended in proportion. Silk-worms must never be stinted in room. At birth, a silk-worm weighs about .01 grain. After first molt, when 5 or 6 days old, it weighs .15 grains. After second molt—8 to 10 days old—it weighs .94 grains. After third molt—15 or 16 days old—it weighs 4 grains. After fourth molt—21 or 22 days old—it weighs 16 grains. When ready to spin up—30 to 33 days old—it weighs 95 grains.

Fig. 7.—**Breeding Room for Silk Worms.**

There are many ways of arranging the worms for feeding. In average "educations," a good way is to have light wooden trays, with bottoms of cheese cloth, mosquito netting, or soft manila paper perforated with holes just large enough for the worms to climb through. The holes may be increased in size as the worms grow. These frames or trays have blocks or feet at corners to raise them a little from the surface and allow a free circulation of air. Worms are voracious consumers of oxygen as well as leaves. A good size for these trays is 1 by 3 feet. When the eggs begin to hatch, lay the plate on a table and place over it and just above it one of the trays, right side up. In the tray place some fresh-chopped osage orange, mulberry or scorzonera leaves. The young worms will, as soon as hatched, climb

through the holes in the bottom of the tray upon the leaves. As soon as the tray is one-third occupied, remove it and place a fresh tray. The eggs usually begin to hatch early in the morning. The period of active escape from the shells may continue for several days, but the worms of each 12 hours' hatch should be kept separate. The eggs not hatched at the end of the third day from the first hatching should be thrown away, as too weak to produce vigorous worms.

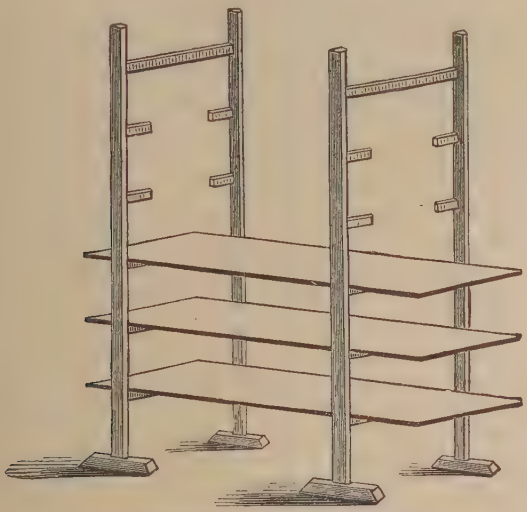

Fig. 8.—**Shelves for Feeding Silk Worms.**

One or more rows of shelves or movable standards should be arranged in the center of the breeding-room—never along the sides. It is impossible to give the room too much fresh air. But too much light is injurious. The temperature must be carefully regulated. Until the first molt, keep the temperature of breeding-room about 73 degrees F.; after first molt, increase to 75 degrees F.; after second molt, increase to 76 degrees F.; after third molt, 78 degrees F.; during last ten days, make temperature 80 degrees F.

Iron stoves must never be used in a room where silk-worms are bred. Open fire-places are good, but the best method of heating the room is by hot-water pipes or tile flues, such as are used in heating greenhouses. In Italy there is made a kind of tile stove or box which gives very good results.

Too much care can not be taken to keep the temperature uniform and make the worms as comfortable as possible during their whole lives. An excess of heat is more injurious than a deficiency, but both are bad. Sudden changes of temperature are very injurious. Fresh

air in plenty must be given, but drafts must be guarded against. A reliable thermometer is an absolute necessity in the rearing-room. Several of these should be hung in different parts of the room, and one outside, but protected from the sun. Do not use cheap, ten-cent thermometers. Get a good one, which can be had for about 40 cents. A good general rule to follow is to keep the rearing-room at all times as warm and free from odor as is customary in the family living-room.

The amount of moisture in the rearing-room is an important matter. The best air is that which is about 65 per cent saturated. In a rough way this may be determined by placing in the room a plate of dry salt. If the salt absorbs moisture enough to feel moist to the touch, the room is too moist. Generally speaking, in the South the air is more likely to be too moist than too dry.

Keep worms at all times free from their own excrement, and from stale, dried-up leaves. Fresh food should be given whenever the last feeding is consumed or withered. The cultivated silk-worm is simply a machine for transforming leaves into silk. The more it eats, the greater the harvest and the larger the profit. The silk-worm as an eater is worthy to bear away the palm even from a school-boy. At least four feeds per day must be given, viz., at 6 a. m., 10 a. m., 2 p. m., 6 p. m. During the last age, 6 or 8 feeds must be given. Experience has shown that an average "education" of silk-worms will, at the temperatures above noted, molt for first time about five days after birth. The intention to molt or cast the skin is shown by the worms ceasing to eat, becoming restless and standing with uplifted head and tail. No food should be given after any worms in a tray show these signs of molting. The periods between successive molts are called ages. Silk-worms pass through 5 ages, lasting about as follows: First age, 5 or 6 days; second age, 4 or 5 days; third age, 5 days; fourth age, 5 or 6 days; fifth age, 8 or 10 days. The progeny of one ounce eggs—about 40,000 worms—will, on the average, consume the following weight of fresh mulberry leaves during the 5 ages above described: First age, 9 to 11 pounds; second age, 25 to 30 pounds; third age, 80 to 110 pounds; fourth age, 275 to 350 pounds; fifth age, 1,600 to 1,900 pounds. Total for progeny of one ounce of eggs, 1,980 to 2,390 pounds of mulberry leaves.

Experience has shown that the above-given quantities of leaves can be gathered from 12 trees annually, or every second year from 24 trees, of white mulberry or its varieties grown in tree form. The trees must be over five years old and in good health, and kept growing vigorously by cultivation and manure.

After each molt, the brood of worms must be "rarified" or spread out. As soon as the worms have recovered from their molt, transfer to fresh trays, and give the worms in each of the former trays just

three times as much room or space as they had before. This is very important, as crowded worms soon become sickly and are liable to breed an epidemic.

In changing the worms into fresh trays, they must never be touched with fingers. By means of perforated-bottom trays and fresh food the worms are easily transferred. Some worms will refuse to pass up into the fresh tray. These, if they are unusually small or inactive, should be thrown away as weaklings. If worms must be transferred by touch, use a fine camel's hair brush. Never squeeze the worms.

The trays with worms feeding are best kept on shelves, made of laths set on edge and nailed to cross pieces. This insures free circulation of air from below. The shelves, if placed one above the other, should be about 24 inches apart. The amount of space required by the progeny of one ounce of eggs is 10 square feet during first age; 30 square feet during second age; 90 square feet during third age; 270 square feet during fourth age; from fourth to spinning-up, 810 square feet. If the worms are kept in trays of uniform size of 1 by 3 feet, the number of trays required at any time is found by dividing the number of square feet above given by 3.

To recapitulate: The requisites for a successful "education" of silk-worms are, 1stly, eggs free from hereditary taint; 2dly, worms of uniform age and constitution; 3dly, plenty of mulberry leaves for food; 4thly, plenty of room to grow and expand; 5thly, plenty of fresh air and an agreeable temperature; 6thly, perfect cleanliness.

Spinning the Cocoon.—About the eighth day of the last "age," the worms begin to show signs of restlessness, such as announced the previous molts. They shrink in size, cease to eat, and wander about throwing out silk threads.

The five accepted signs of completion of growth in the silk-worm are as follows:

1. The worms cease to eat, wander about aimlessly, and stand with uplifted heads.

2. When viewed horizontally in the direction of a lighted window the worms appear of a plum-yellow or almost transparent color.

3. The worms crawl upon the edges of the trays and show a determination, not previously seen, to climb.

4. The rings or segments of the body contract and change into a lighter color.

5. The skin becomes wrinkled and the entire body becomes soft and satiny.

Fig. 9.—**Brush for Spinning the Cocoons.**

The brush for the worms to spin upon must then be prepared. These are dry twigs of oak, chestnut or other trees free from odor and gum. The twigs should be copiously branched and about 18 inches long. Place them in bunches along the shelves on both sides, at intervals of 12 inches. Tie the interlacing branches so that the arches will not fall apart. If the worms have been reared in trays, place the trays under the arches. The worms will soon mount into the brush and begin to spin their cocoons. There are a few worms in every brood which refuse to mount into the brush. To accommodate these, remove the trays from beneath the arches and place over each tray a few of the brushy branches. These worms will spin their cocoons in the branches thus supplied. If any refuse to climb and appear sluggish or sickly, after the 12th day of the last age, throw them away.

During the last few days of their larval life the worms give off an enormous amount of matter in the form of gas. Special care must therefore be taken to keep the room well ventilated, yet drafts must be avoided.

The period of mounting the brush and spinning the cocoon is the most critical in the entire life of the insect. Neglect or wrong treatment at this period is apt to prove fatal to the creature and to the owner's profit. Until the danger is passed and the cocoon is spun someone should be constantly with the worms to ensure that everything is as it should be.

Usually four-fifths of the worms will have mounted within 24 hours after the first one did. But there need be no hurry in pushing the mounting. Give them all the time they want. Those which remain and continue to feed after the 24 hours are over should be removed to

a separate room which is heated 5 degrees above the main room, and there fed as much as they want. The extra heat will probably bring them to the mount within 24 hours. Return them when they show intention to mount.

Remove the trays and clean the woodwork as soon as all the worms are mounted. Increase the ventilation to the utmost. Drafts need no longer be feared after the worms have spun their floss covering. Heat is what is now to be avoided. Sprinkle the floor frequently to cool the room. Remove at once any worms which become sick or die in the brush. If two worms begin to spin close together, with a camel's hair brush or a twig remove one to a distance. While the worms are spinning their cocoons the utmost silence and quiet must be maintained. Whenever the worms are disturbed at this time they cease work. This makes a kink in the filament where it will probably break in reeling.

The temperature of the room must be kept as near as possible to 80 degrees F. during the process of spinning, which usually lasts three days. It is very important that the temperature be 80 degrees F., neither less nor more. If lower, the silk does not flow freely in the worm's spinnerets. If higher, the worm is liable to premature exhaustion and may fail to complete the cocoon.

The worms which show no signs of wanting to spin, after general spinning has begun, should be fed sparingly until they do. But the trays are likely to soon become foul from the excrement of the worms which have already mounted. Cloths must be used to keep the trays clean at this stage. The worms in the brush must also be watched closely. If two or more are so close together that they are likely to spin compound cocoons, the worms must be gently separated by aid of a soft camel's hair brush. Double cocoons are worthless for reeling. Such cocoons must be sold for waste silk, which is worth only one-quarter as much as reeled silk.

When the cocoon is completed—which requires about two days—the worm within casts its skin for the fifth and last time and takes on the form of *pupa* or *chrysalis*. In this condition it is surrounded by a hard, horny shell. The interior of the worm melts up and reforms into the shape of the winged moth. The process of transformation requires 12 to 15 days. At the end of this period, if the chrysalides have not been killed or "choked," the winged moth pushes her way through one end of the cocoon. Such pierced cocoons are useless for reeling, but may be used for carding as floss silk. They are worth about one-fifth the price of prime choked cocoons.

The cocoons for reeling should be gathered from the brush about 10 days after the first spinning began. The brush is carefully taken apart and the cocoons, which are only lightly attached, are separated from the branches with the fingers. They are at the same time sep-

arated into grades according to color, size and firmness. The cocoons, especially those which lack firmness, must be carefully handled, or the chrysalis within will be injured, will putrefy and stain the silk, which then has only the value of waste silk. After classifying the cocoons, the largest and firmest should be picked out for "seed" for next year. For each ounce of eggs, or "seed," that is wanted, 200 cocoons must be saved. The remainder of the cocoons are to be at once "choked" to kill the chrysalides. "Choking" is usually accomplished by putting the cocoons into a covered, perforated-bottom tin vessel like a kitchen colander and setting this for one-half hour over a kettle of vigorously-boiling water. A few chips of wood should be put into the kettle to prevent the bubbling water from spattering and staining the cocoons. Instead of steaming, the cocoons may be choked by putting them into an oven and heating to 140 degrees F. for 4 to 6 hours, or as long as a humming noise can be heard when the cocoon is placed to the ear. After "choking" by steam the cocoons should be thinly spread on a sheet in the shade and allowed to dry out thoroughly. This is not necessary when dry heat is used. After the cocoons are dry, they will keep indefinitely, provided they are preserved from weevils and mice. It is usually best, however, to sell at once. It is not desirable for any American silk grower to attempt to reel the silk at home. It is impossible, by the utmost skill even, to make as good a quality of silk by hand-reel as can be made by the improved automatic power reel. In communities where as much as 10,000 pounds of fresh cocoons are raised annually, it will pay to put up a co-operative reeling establishment. A reel may be run by steam, water or electric power—using about one-half horse power per basin. To produce 1 pound of raw silk requires 12 pounds of fresh or 4 pounds of choked and dried cocoons.

The Production of Eggs.—The production of eggs for sale is, in all old silk regions a special branch of the industry, carried on by those who make a specialty of it—just as seedsmen grow seed for use of gardeners. But in all new countries each gardener and silk grower must, at first, produce his own seed.

We have already shown that for each ounce of "seed" 200 of the finest cocoons must be laid aside. These cocoons, at market price, are worth about 30 cents. The ounce of seed they will produce is worth, at market price, about $2.50. The selected cocoons are first with a needle and thread carefully strung into chains of 3 or 4 feet long. The thread should only pass through the loose, floss silk at middle of cocoon. Hang the cocoons from ceiling in a cool, dark attic or dry cellar. If very numerous they may be laid upon a clean, cloth-covered table in a layer not over two inches deep. They should be

stirred once a day so as to give all an equal chance to secure air. If kept on a table the legs of the table must be stood in buckets of water to keep off ants and mice.

Fig. 10.—**Silk-moth and her Eggs in a Cloth Pocket.**

During the chrysalis or pupal stage, and the subsequent period of egg-laying, every expedient must be practiced to keep down the temperature, which, on no account, should rise above 73 degrees F. The best temperature during the pupal and egg-laying stages is 68 to 70 degrees F. Usually in the Southern States during June this temperature can be secured only in a dry cellar, and this will probably be found to be the best place for egg-laying. Where the temperature rises above 73 degrees the eggs are apt to be poorly fecundated. The same happens if the temperature falls below 68 degrees during egg-laying.

The moths will emerge within 12 to 18 days from date of spinning first cocoon. They usually appear in early morning, and cluster upon the cocoons. Though they have wings, the moths never attempt to fly. They have no mouths, and therefore eat nothing. The sole end and aim of their existence is to produce and lay eggs. Then they die. Before the moths emerge, squares of clean cheese cloth about 3 by 3 inches are prepared—one-half as many squares as there are cocoons. Instead of squares, bags or pockets of cheese cloth 3 by 3 inches, with a flap of one inch at upper end, may be used, and are much better than the simple squares. The cloths should have been

previously boiled in clean water for one-half hour and then dried, to kill chance spores of disease and remove from cloth gum or other substances which might injure the eggs. The moths will issue from 5 a. m. to 8 a. m. The two sexes are usually about equal, but it often happens that the male moths issue first. The sexes are easily distinguished by the slender body and longer antennæ or "feelers" of the male, and his greater agility. The female is much larger and heavier, being gorged with eggs. The sexes couple in an hour after issuing and while still clinging to the cocoons. They are to be left so for about six hours. The room should be kept very dark and quiet, but with plenty of fresh, moist air. Temperature about 70 degrees F. After six hours, place the prepared cloth squares or bags, turned inside out, and separated by about two inches, upon a flat table or shelf. Take up a couple of moths and separate them by gently pulling on the wings of the male, throw the male into a basket prepared for that purpose. Allow the female to rest for a few minutes on a clean board, until she has ejected a quantity of reddish fluid. Then pick her up and place her upon one of the cloth squares or pockets. She will at once begin to lay her eggs, and will keep it up for about 36 hours, during which time she will have laid between 300 and 400 eggs. She dies soon after finishing, but must not be thrown away.

Fold over her one corner of the cloth on which she laid her eggs, and pin her there. The body must be so kept until it has been examined with a microscope to determine whether or not she was free from the germs of the Pebrine and Flacherie diseases. The moth is crushed in a mortar with a little distilled water, and a drop examined under a lens magnifying 400 diameters. If any moth shows evidence of this disease, the body and all the eggs she produced must be burned, as this disease is hereditary and contagious. Eggs produced by a diseased moth are worthless, as the worms would not live through their complete life cycle, and would convey the disease to other worms of same "education."

It rarely happens that the cocoons set apart for egg production give out more females than males. When this occurs, after the sexes of those coupled have been together for two hours, they may be separated by gently pulling on wings, and the males may be used over again for virgin females. In such a case the moths must not be separated for 24 hours. This is seldom necessary. After the eggs are deposited upon the cloths, they soon harden and become glued to the cloth. No further treatment is required, other than the microscopic examination of the mother insect. This work requires greater skill and more expensive appliances than the average silk-grower possesses. It is usually best to send the cloths with eggs and mother attached to some scientific laboratory for examination. It is sufficient to send the moth alone, and if a number is placed upon the cloth and the same number at-

tached to the moth, the eggs of any particular moth can be identified. But confusion is liable to arise by misplacing numbers. It is safer and better to keep the moth and her eggs together until the microscopic examination has been made. After the eggs are certified free from disease, they should be packed lightly, still on the cloths, in a ventilated tin case and hung from the ceiling of a cool, dry room. Rats, mice, ants and weevils are all very fond of silk-worm eggs.

We have already seen that the eggs can not be made to hatch until after 6 or 8 months. No particular care is needed as regards temperature, but the eggs must be kept dry and not be exposed to direct sunlight. Certified eggs of the best races are worth in the market $2.50 to $3.00 per ounce. For Southern silk growers the large yellow races of Italy are specially recommended.

The white Japanese races produce finer silk, but in smaller quantity, and are not as valuable when growing for the general market.

When once a good local variety of silk-worm has been evolved that should be carefully bred and improved, and made the standard of the locality. Growers can not be too strongly cautioned against introducing strains of worms of unknown origin or value. Acclimated breeds are best. Well-bred and constantly-selected strains do not degenerate. The American-bred silk-worm is equal to the best, and when a local race has been created it is folly to supersede or mix it with foreign blood.

Silk growers should form local associations and endeavor to build up a local sentiment towards creating and preserving the local, standard brand, and for establishing co-operative filatures and sales-markets.

Silk Gut.—Silk gut is an article of interest and use for rod and line fishermen. Gut is made from the same substance as raw silk, but in procuring gut, the worm, just before it is ready to spin up, is killed by throwing it into strong vinegar or weak acetic acid for an hour or two. The silk spinnerets are then opened and the silk is forcibly drawn out into two threads very much thicker than that the worm naturally spins. These threads are steeped and hardened in cold water, and afterwards washed in a solution of castile soap. The threads are next manipulated and rubbed between the fingers until a thin epidermis peels off. The gut is finally dried in the shade. In some places the gut is bleached by sulphur fumes after drying. Each worm gives about 18 inches of thread from each spinneret. The threads are usually assorted and put up in bundles of 100. They are sold wholesale in dozen bundles at about $2.25 per dozen. It requires about 18,000 of these threads to weigh one pound. The demand is pretty good. At present the supply comes almost wholly from Spain. The gut from the Indian silk-worms is much stronger and better than that from the common worm.

The methods of caring for the silk-worm detailed in this chapter apply strictly only to the mulberry worm. The three Indian worms described in this BULLETIN will require somewhat different treatment, which is detailed in the special descriptions of these worms. In a general way, we may state that the Indian worms may be reared indoors on trays, but being larger will require more room and more food than the mulberry worm. The temperature, too, must be kept about 15 degrees F. higher than is good for the mulberry worm. The food leaves and air of room must be kept very moist. The Indian moths do not lay their eggs on cloth, but in boxes of straw or loose and dry leaves. The cocoons are spun on brush after the manner of the mulberry worm. The Indian cocoons must be macerated in 3 per cent soda or potash solution instead of pure water.

V.—REELING THE SILK.

Reeling silk, or, in other words, unwinding the silk from the cocoons, combining several of the worm's threads into one compound thread and reeling this into skeins, is a process of manufacture which about doubles the value of the natural silk. Skill in reeling has become hereditary among the silk-growing peasantry of Italy, but modern automatic, power reels can produce a much better grade of silk from same cocoons than the most skilful Italian hand-reeler. The hand-reel is now obsolete and can not be profitably employed in competition with power reels. It should have no place in the American industry.

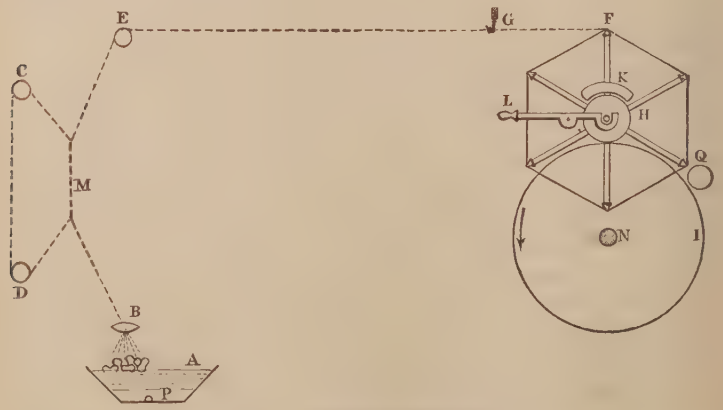

Fig. 11.—**Automatic Power Reel.**

A, basin of water; B, "eye" of basin for uniting several threads; C and D, pulleys for pressing water out of thread; E, support; G, travelling pulley for spreading the silk over the reel, F; N. I, driving wheel; L, break; P, waste ends from cocoons.

Silk reelers classify cocoons into eight grades, viz:

1. Prime cocoons. Hard, fine-grained, unspotted cocoons.

2. Calcined cocoons. These have dead, petrified worms within. They may, however, be of first-rate quality.

3. Pointed cocoons. These are thinner at the pointed end than at other ,and do not reel well.

4. Large, but soft cocoons. These have coarse, brittle fiber and are difficult to reel.

5. Soft cocoons. These are loosely spun, resembling floss silk. They can not be reeled, but must be combed.

6. Double cocoons. These are cocoons formed by two worms in common, and have their filaments intertwined at one end. They can not be reeled.

7. Perforated cocoons. These have one end perforated by the escaping moth. They can not be reeled.

8. Stained cocoons. These are cocoons stained by the death and putrefaction of the worm within, or by filth from without. They may vary in value from second grade to worthless.

In forming the cocoon the worm works from within. It first throws out a loose, irregular covering, which forms the "floss" of the cocoon. After this it proceeds in a more regular manner, laying down the silk in close "figure-of-eight" loops. These are cemented by a sort of gum, which makes a continuous and very tough fabric from the different and separate strands of silk. To unwind this silk, the loose or floss silk is first torn off with the fingers. This silk is combed and spun in same way as wool. The tough inner part, called the "pod," is next thrown into a basin of water kept at a temperature of about 150 degrees F. Here it is beaten and stirred with a small whisk-broom until the gum softens and the silk thread shows signs of falling apart. One of these threads is caught on the brush of the broom and unwound until the outer end is found. Four or five similar threads are caught and passed through a glass or brass "eye" on the edge of the basin. The compound thread thus formed is twisted upon itself or upon another thread to get rid of surplus moisture. Some reels pass the thread through a heated box to further dry it before it is wound upon the drum. The length of the natural thread spun by the worm is about 4,000 feet. Its diameter is greatest in the center and tapers to both ends. In reeling the compound thread it is of prime importance to have the thread of uniform diameter throughout. To accomplish this, a fresh thread from the basin must be added from time to time to make up for the growing thinness of the other threads. This requires great judgment on the part of the reeler, but is accomplished automatically and with far greater precision by the improved reels.

The best reel is the Serrell, an American invention. Good reels are also made by Pozzi Bros., at Milan, Italy; by Giovani Battaglia, Luino, and Pierino & Cecco, Udine, Italy; and Berthaud & Son, Lyons, France.

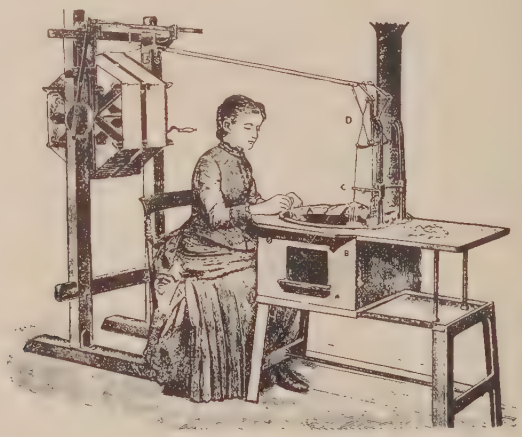

Fig. 12.—**Italian Silk-reel.** A, basin; B, charcoal heater; C D, guides; E, drum.

The American reel costs about $80.00, the Italian and French reels about $50.00. Prices in either case do not include power or fittings. With either of these reels, run by steam or water power, a woman with a girl to help can reel from one and a half to two pounds of raw silk per day. The following figures as to cost of reeling are given by a Consul of the United States in Italy:

Wages of a woman reeling, per day	$0.55
Wages of girl brushing, per day	.15
Cost of fuel	.35
Rent of machine and room	.15
Interest on cost of cocoons	.20
Loss on cocoons	.08
Taxes, insurance, etc	.10
Total cost of reeling 2.2 lbs. silk	1.58
Less value of waste silk	.08
Net cost	1.50
Cost per pound of raw silk	.72½

Reeling mills or "filatures" are in Europe usually connected with weaving factories, or are owned by commission houses, who gather up the cocoons from a large district. But any neighborhood which pro-

duces at least 10,000 pounds of fresh cocoons annually may profitably establish a local filature. A single "basin" or reel costs from $40.00 to $80.00, not including power or fittings. This will reel from one to two pounds of skein silk per day of ten hours. In 300 days a single "basin" will work up 3,000 to 4,000 pounds of fresh cocoons. A single basin, however, can be profitably run only in connection with some other industry requiring power from which the reel may borrow. The smallest custom filature that can be profitably established has three basins, and will work up about 10,000 pounds of cocoons in a year. With the improved automatic reels silk reeling calls for no more mechanical skill than cotton ginning. There is no reason why silk reels may not be established in connection with cotton gins.

The following suggestions for reeling silk are offered by an experienced Italian reeler:

The room must be dry and free from drafts. The water used must be of the softest and free from sediment. Different qualities of cocoons require different temperatures in the water, varying from 140 degrees F. to 200 degrees. The water must never boil. Only carefully assorted cocoons of the same grade should be put into the basin together. Maceration requires from two to seven minutes. The brushing is accomplished with small whisk-brooms. The cocoons are beaten and stirred until an end is caught, which is stuck on the rim of the basin until several, usually five, are found; these are then taken together and passed through the "eye" and over the pulleys upon the drum. The reel must be turned as fast as the cocoons will unwind. If the cocoons tend to rise from the water, the water is too hot. When a skein is finished, the end must be tied with a white rag or a cord with a card attached so that the end can be readily found. The skein must not be removed from drum until it is thoroughly dried, which requires about 10 or 12 hours.

VI.—Diseases of Silk-Worms.

The silk-worm is subject to several grave diseases, which are described below. As the worms are reared under cover and with constant attention, they are not subject to the attacks of other animals, except mice and weevils.

1.—Pebrine.

Pebrine is a bacterial disease, which in years past has wrought enormous damage in the silk-growing regions of France and Italy. Thanks to the researches of Louis Pasteur, this disease is now easily prevented. Pebrine is hereditary, being transmitted to the eggs by the mother moth. To prevent the appearance of pebrine in a rearing-room, only eggs certified by a competent microscopist to be free

from germs of pebrine should be incubated. A microscope for examining moths for pebrine must magnify at least 400 diameters. A good instrument will cost about $30.00. We recommend those made by Bausch & Lamb, of Rochester, N. Y. If infected eggs are incubated, the worms will die before completing their last molt, and will in the meantime infect the healthy worms in same room. Pebrine is

Fig. 13.—**Pebrine.**

as contagious and destructive to silk-worms as cholera is to human beings. When silk-worms die during the rearing process from whatsoever cause, the dead worms should be removed and burnt, and the healthy worms removed to a fresh tray or clean shelf. No dosing or topical treatment for pebrine is of any value. The use of eggs infected by the germs of pebrine is the main cause of some recent failures of silk growing in the United States.

2.—Muscardine.

Muscardine is a disease due to a parasitic fungus which attacks the worms. The same fungus attacks other insects, especially the house-fly. House-flies may transmit the disease to silk-worms. Silk-worms are more commonly attacked by muscardine during their last

"age." The attacked worm dies suddenly and soon discolors and becomes stiff and hard. In about 24 hours thereafter the worm becomes covered with a whitish powder, which is the spores or "seed" of the fungus. These spores may be borne about by the air and so be carried to still healthy worms. The spores also are carried to the walls of the room and upon the shelves, etc., used in rearing the worms. In such places the spores of the fungus retain their vitality for over a year. Unless the room and all woodwork is thoroughly cleaned and fumigated, these spores are certain to infect the new brood.

The only treatment for this disease is cleanliness and thorough disinfection of the breeding-room before the worms are hatched. Houseflies should be kept out of the breeding-room at all times. Dead worms, or even those sick, should be removed and destroyed as soon as observed. Beginners in silk growing must, however, be careful not to confuse the natural sickness of the worm preceding molting with muscardine or other contagious diseases.

3.—Grasserie.

Grasserie, also called *Jaundice*, is generally present when the broods are large and where succulent food is used. Worms fed upon osage orange leaves are much more liable to this disease than those fed on mulberry. This disease is dangerous where the worms are kept in large numbers. The exact cause of the disease is not well understood, but it is believed to be due to bacteria acting upon the worm when its digestive apparatus is enfeebled by too succulent food. The only practicable treatment is to avoid wet and succulent food—feeding only leaves which have been picked and kept under cover for 12 or 14 hours. The leaves should not be gathered when wet, or if they must be, they should be dried under cover before being fed. To prevent fermentation the leaves while drying must be frequently stirred with a wooden—never iron—fork.

Mulberry leaves grown on wet soil are very liable to cause jaundice, as are those from rank-growing sprouts. On the other hand, old and tough leaves fed to very young worms are equally liable to cause digestive trouble. The following three points are of capital importance in feeding:

1. Feed only dry, clean, healthy leaves.
2. Feed young leaves to young worms—old leaves to old worms.
3. If a change of feed must be made from one species of plant to another, feed the new kind very sparingly at first, so as to gradually effect the change.

The presence of Grasserie always indicates inefficient care on part of silk grower, or bad management in the rearing-room. Observe the same precautions in regard to cleanliness and destruction of diseased and dead worms as above recommended for pebrine.

4.—Flacherie.

Flacherie, also called *Pallor*, is now the most dangerous disease of the silk-worm, and one for which we know no remedy.

The symptoms of pallor are drowsiness and diarrhœa. The body first grows soft and flabby, shrinks and turns black. Sometimes the worms burst and give out a very offensive odor. Pallor is always worst when the worms are crowded, and when the trays and shelves

Fig. 14.—**Flacherie.**

are not kept scrupulously clean, or when wet or diseased leaves are fed. A high temperature is also very conducive to this disease. The only practicable treatment is that advised for the other diseases—scrupulous cleanliness, plenty of fresh air, good, but not too succulent food, and the early hatching of the worms so as to insure their spinning-up before hot weather comes on. This disease is hereditary and contagious.

5.—Tripès.

Tripes is another name for suffocation. The silk-worm breathes through spiracles or holes in its sides. When by the accumulation of dirt, or when the worms are so crowded that they are compelled to

overlie each other, these breathing holes become clogged and the worm literally suffocates.

The remedy for Tripes is the obvious one of perfect cleanliness, abundant ventilation, and plenty of room for the worms in the trays.

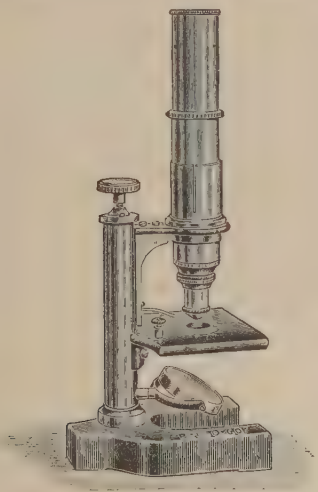

Fig. 15.—**Microscope for Examining Moths for Pebrine and Flacherie.**

6.—Chilling and Overheating.

Sudden and great changes in temperature are very bad for silk-worms. A single chill or a "hot wave" may ruin in a day an entire batch of worms! A uniform, comfortable temperature night and day in the rearing-room is an absolute necessity in producing high-grade silk.

VII.—General Rules for Silk Growing.

1. Incubate only eggs certified to be free from pebrine.
2. Clean and fumigate the incubating and rearing-rooms before the eggs or worms are placed therein.
3. Practice the most scrupulous cleanliness and attention to feeding and ventilation during the entire rearing period.
4. Discard all eggs which remain unhatched after three days from time the first eggs of same brood hatched.
5. Cut or hash the leaves for the first five days after the worms have hatched.
6. Never feed dirty, wet, cold or diseased leaves. Pick the leaves 12 hours before they are to be fed, and cover them with a clean sheet. Do not keep the leaves in same room with the worms. After the first age unchopped leaves may be fed.

7. Feed the worm in perforated, cloth or paper-bottomed trays laid on lathed shelves.

8. Change the trays or papers for clean ones as often as they become soiled. Throw away all sick worms every time the litter is changed. This does not refer to the sickness which precedes molting.

9. Separate and "rarify" the worms as often as they become crowded. Give plenty of space to expand in.

10. Never place together worms from different lots of eggs, or worms which have hatched on different days.

11. Never disturb worms while they are molting.

12. Prepare before hand for spinning the cocoons an ample supply of dry, clean, odorless and gumless twigs.

13. Form the arches with these twigs over the shelves or trays as soon as the worms show signs of wanting to spin, which is usually about the eighth day of the last "age."

14. Remove the cocoons from the twigs on the tenth day from first spinning-up.

15. Assort the cocoons carefully according to size, color and firmness.

16. "Choke" the cocoons for reeling within 24 hours after removal from the twigs. Choking may be done by live steam or hot air.

17. If cocoons are selected for "seed," take the finest ones. String them on threads and hang in a dark room. For one ounce of seed, take 200 cocoons.

18. Cause the moth to deposit on squares or pockets of cheese cloth 3 by 3 inches. Let eggs remain on these cloths until hatched.

19. Keep the moth and eggs together until the moth has been examined by a microscopist for germs of pebrine.

20. Never buy or sell any but certified disease-free silk-worm eggs.

VIII.—The Future of the Silk Industry in the United States.

The United States is now the greatest silk manufacturing country in the world. It consumes annually over 25 per cent of the world's total output of raw silk. Yet, at present, not one pound of American-grown silk is found upon our markets. Experience has shown that the average of American-grown silk is superior to the average of that of any other country. Our climate seems to be specially adapted for the production of the finest grades of fiber. With millions of acres of cheap land suitable for growing the mulberry, and with our intelligent and inventive population, there seems no reason why we should not grow all the silk we manufacture, and even export fiber to other countries.

The following figures relating to importations and silk manufactures in the United States are taken from the census of 1900, and the

annual report of the Bureau of Statistics of the United States Treasury for the same year:

Articles Imported.		Quantities in Pounds.	Value in Dollars.
Unmanufactured silk—			
Cocoons	duty-free	30,004	$18,235
Raw, or as reeled from the cocoon	duty-free	11,259,310	44,549,672
Waste	duty-free	1,784,404	761,853
Total unmanufactured			45,329,760
Manufactured silk—			
Clothing, ready-made, and other wearing apparel	Average advalorem duty 53.95 per cent.		1,657,641
Dress and piece goods			15,425,997
Laces and embroideries			3,206,857
Ribbons			1,811,644
Spun silk, in skeins, cops, warps, or on beams		2,420,552	3,723,348
Velvets, plushes, and other pile fabrics		708,354	2,316,115
All other			2,752,771
Total manufactures			30,894,373

SILK GOODS IMPORTED INTO THE UNITED STATES FROM 1884 TO 1900 INCLUSIVE.

Year.	Declared Value in Dollars.	Duties Collected in Dollars.	Year.	Declared Value in Dollars.	Duties Collected in Dollars.
1884	$38,030,574.00	$18,962,210.34	1893	37,919,948.92	20,310,258.74
1885	28,106,797.57	14,000,210.04	1894	24,160,529.28	12,824,084.74
1886	28,055,854.94	13,938,096.61	1895	31,023,148.18	14,739,550.46
1887	31,264,276.58	15,546,300.70	1896	26,627,731.71	12,504,006.17
1888	32,942,629.03	16,351,685.48	1897	26,517,092.51	12,421,970.09
1889	34,956,728.77	17,342,571.54	1898	22,639,596.93	12,231,680.65
1890	38,246,787.20	18,945,959.24	1899	25,026,504.01	13,506,312.23
1891	37,300,387.27	19,368,764.49	1900	30,358,777.39	15,771,795.93
1892	31,442,180.31	16,965,637.03			

SILK MANUFACTURES IN UNITED STATES IN THE CENSUS YEARS 1890 AND 1900.
(Special Report, Census Bureau.)

	1900.	1890.	Per Cent of Increase.
Number of establishments	483	472	2.3
Capital	$81,082,201	$51,007,537	59.0
Wage-earners, average number	65,416	49,382	32.5
Total wages	$20,982,194	$17,762,441	18.1
Miscellaneous expenses	10,264,208	4,259,623	141.0
Cost of materials used	62,406,665	51,004,425	22.4
Value of products	107,256,258	87,298,454	22.9

IX.—Climatic and Labor Factors in Silk Culture.

Italy is second only to China in the quantity of her output of silk; but in quality and value she surpasses by far every other country. The highest grade of Italian silk is produced in the three Northern provinces of Piedmont, Lombardy and Venetia. These provinces form a vast alluvial plain extending from the 45th to the 46th parallels of north latitude, from east to west about 230 miles. This plain is watered by the river Po and its tributaries. It lies just at the foot of the Alps and is swept by cold wintry winds, which frequently cause the thermometer to fall below 10 degrees F., or 22 degrees below the freezing point. Besides silk —the main agricultural staple—the most important products of this region are wheat, corn, barley, rye, millet and rice. Dairying, especially cheese making, is an important industry.

During the year 1895 in these three provinces silk growing furnished the principal employment and support of about 4,000 men, 10,000 women and 30,000 children. The climatic data, given on the following pages, shows that the best silk-growing region of Italy has a climate very similar to that of the central Northern States of the Union.

In the United States, as elsewhere, silk growing must be looked on mainly as work suitable for labor otherwise unproductive. The actual cost of growing silk has never been studied in this country. But we have very complete figures for European countries. The following is a sample calculation of the cost of raising the produce of one ounce of silk-worm eggs in Italy:

Dr.—	
To "seed," one ounce	$2.00
To mulberry leaves for feed	12.00
To rental of trays and apparatus	4.00
To labor, 30 days	9.00
To heat and light	2.00
To brush for cocooning	1.00
Total	30.00
Cr.—	
By 130 pounds of cocoons @ $0.38	49.40
By resulting manure	1.50
Total	50.90
Less cost	30.00
Net return	20.90

In America under the conditions we have named the cost of labor may be omitted from our calculation. The cost of mulberry leaves may be placed at about one-fourth that given above. With a duty of 25 per cent *ad valorem* on imported reeled silk it is probable that American-grown cocoons will bring not less than 50 cents per pound! The best class of Indian cocoons now sell in the London market for about 75 cents per pound. This class of silk can be produced in the South Atlantic, Gulf and Lower Mississippi Valley States as cheaply as in India. It will add enormously to the value of our other textile fibers, since these silks are well adapted for mixing with other fibers to make durable goods. The castor-oil plant flourishes luxuriantly in the South, while many of the other favorite food plants of the Indian worms are known to thrive in the hot climate and light soils of the cotton region.

In practical silk growing, at least eight-tenths of the entire labor is done by women and children of the family—whom our social customs will not permit to do ordinary field labor—and by men too old or too feeble to do even the lighter kind of field work. Such labor as this has little or no commercial value. The establishment of silk-growing industry in the United States means the utilization of this labor now unproductive. It will mean the addition to many families of an increased income of from $60 to $250 per year without much outlay for material or any hardship to the workers. The work of tending silk-worms is easy, clean and pleasant. It is work that children and women of culture and refinement delight in. By raising from two ounces of eggs two broods of silk-worms annually, a child of twelve or fourteen years may, in ten weeks in early spring, earn money enough to purchase clothing and school books for the entire year, or the means of taking a summer vacation and travel. There are at least 50,000 families in North Carolina which can each year rear the product of four or five ounces of silk-worm eggs, and this without interfering with the regular work of the household. The additional income thus produced would amount for the entire State to over $3,000,000. This large sum being produced by the labor of the indoor members of the family, would naturally go for purchasing increased comforts and luxuries for these. It would add just so much to the prosperity and enjoyment of rural life. It will in a single generation elevate the entire social condition of our country people, besides inculcating habits of self-reliance and thrift.

The reeling of the raw silk about doubles its value, therefore, if the $3,000,000 worth of silk-worm cocoons which the State may produce are reeled within the State, it will double the people's income from this source, although silk reeling is fit labor for otherwise productive men and women. Silk reeling can not be economically done by household labor.

In the silk-growing districts of Southern France, which adjoin the chief silk-growing region of Italy, the following scale of wages are quoted in a recent Consular Report of the United States Department of State: "Male laborers per day, 55 cents to 60 cents; male laborers per week, $3.30 to $3.60; male laborers per month, with board and lodging, $7.00 to $9.00. Female laborers receive about one-half the wages of males. The above figures are for ordinary farm labor only. For skilled labor, such as grafting vines, men get 80 cents to $1.00 per day. An ordinary day's work does not exceed seven hours. A day's work is nominally twelve hours, but laborers are allowed three rests of one and one-half hours each. Even then the laborer works with the placid deliberation of a man working against time. Their tools are rude and awkward."

The same report quotes for ordinary farm labor in the silk-growing districts of Spain the following wages: Men, 40 cents to 50 cents per day; in harvest, 70 cents to $1.00.

In Spain women are employed only at light work, such as gathering grapes, for which they receive about 15 cents per day. A day's work is 9 hours.

The report of the North Carolina Commissioner of Labor for 1899 quotes the following wages for farm labor in this State:

Men, per day, 50 cents; per month, $8.90, with rations and house equivalent to about $6.30. Women, per month, without rations, $5.27. Children, per month, without rations, $3.58.

Farm wages in North Carolina, compared with those abroad, are not higher than in Italy or Spain for the same class of work. Considering the greater cheapness of food, lower taxes and freedom from military service in America, even were American wages higher than they are, the more general use of labor-saving tools and our more intelligent labor will enable us to compete with similar labor anywhere.

TEMPERATURE AND PRECIPITATION.

DRAGUIGNAN. DEPARTMENT VAR, FRANCE.

Latitude 43° 32′ N. Longitude 4° 8′ E (Paris). Elevation 584 feet.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual
MEAN TEMPERATURE—DEGREES F.													
1883	41.7	46.8	42.6	51.4	59.4	67.5	73.0	74.5	66.4	54.0	49.5	43.0	55.8
1884	42.4	45.7	49.5	53.4	62.4	63.0	72.9	72.0	65.3	52.0	43.5	42.1	55.4
1885	39.0	47.3	48.7	53.8	60.1	67.5	74.3	74.1	64.2	53.2	50.9	43.5	56.4
1886	39.9	44.4	47.1	53.4	60.8	65.1	74 3	73.0	65.3	58.6	48.4	42.4	55.1
1887	37.6	41.2	47.7	52.0	58.1	69.6	73.8	73.4	64.6	49.6	48.0	41.9	54.8
AVERAGE PRECIPITATION, INCHES AND HUNDREDTHS													
1883	6.92	4.00	2.18	4.69	7.83	3.13	0.35	0.30	3.82	1.14	2.24	0.52	37.12
1884	0.84	1.06	2.30	5.02	2.41	4.07	0.37	1.02	3.10	1.43	0 32	3.32	25.26
1885	3.06	3.26	0.89	5.55	0.86	6.00	2.37	3.11	2.54	9.02	5.76	0.18	42.60
1886	4.44	3.61	2.64	3.47	1.17	0.58	0.75	1.46	4.75	14.27	6.22	1.61	44.97
1887	6.02	6.61	1.77	4.37	0.63	1.58	0.87	2.16	0 59	0.76	6 50	2.91	34.77

NORMAL TEMPERATURE AND PRECIPITATION IN LOMBARDY, ITALY.

Stations.	Altitude Above Sea Level	January.	February	March.	April.	May.	June.	July.	August.	September	October	November	December	Annual.	Length of Record.
						MEAN TEMPERATURE—DEGREES F.									
	Feet.														*Years.*
Como	367	34.0	38.5	44.8	52.5	60.1	67.1	72.1	70.0	63.0	52.9	42.3	36.3	52.8	11
Sondrio	1,191	33.4	38.8	44.8	53.4	60.3	67.1	72.3	69.6	62.8	52.9	41.9	36.1	52.8	2
Milan	482	33.4	39.9	46.8	55.8	63.5	70.7	76.5	73.9	66.9	55.6	43.5	36.1	55.2	23
Brescia	564	34.9	40.6	47.1	55.8	63.1	70.0	75.2	73.2	66.9	55.8	44.6	37.0	55.4	18
Bergamo	1,253	35.8	40.5	45.3	53.4	61.2	68.2	73.6	71.8	65.3	54.9	43.7	38.3	54.3	9
Pavia	322	33.1	39.7	46.9	55.9	63.7	71.1	76.1	74.1	67.1	55.6	43.5	36.1	55.2	17
Cremona	223	32.5	39.2	46.2	55.0	63.7	70.9	76.6	74.1	67.1	55.8	43.5	35.8	55.0	5
Mantua	131	35.1	40.5	47.8	57.0	64.9	72.7	78.3	75.7	68.7	57.4	44.8	37.8	56.7	17
						AVERAGE PRECIPITATION—INCHES.									
Aosta		1.85	1.81	1.22	1.77	2.20	1.46	1.18	1.81	1.73	3.62	2.32	1.57	22.54	29
Biella		1.57	1.61	3.70	5.55	6.93	5.79	4.37	4.53	3.39	6.30	4.10	2.84	50.68	13
Milan		2.40	2.24	2.60	3.31	3.94	3.23	2.84	3.23	3.46	4.68	4.37	2.91	39.21	116
Brescia		2.05	1.81	2.16	3.66	4.41	5.04	3.70	3.31	2.40	3.82	4.06	2.56	35.98	10
Verolanova		2.44	2.36	2.13	4.88	4.84	3.50	3.11	2.52	2.28	4.17	4.10	2.52	38.85	10
Pavia		2.20	1.97	2.16	2.84	2.80	2.16	1.89	1.93	2.52	3.70	3.35	2.36	29.88	63
Mantua		1.30	1.30	1.73	2.36	2.80	1.97	1.81	1.97	2.40	3.31	2.72	1.69	25.36	39

TEMPERATURE AND PRECIPITATION.

SILCHAR, PROVINCE OF ASSAM.

Latitude 24° 49′ N. Longitude 92° 50′ E. Elevation 104.3 feet.

Jan.	Feb.	March	April.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec	Annual	Length of Record. Years.
NORMAL MONTHLY TEMPERATURE.													
63.4	66.9	73.4	77.9	79.7	81.7	82.4	81.9	81.8	79.8	73.2	65.9	75.7	18–19
NORMAL MONTHLY PRECIPITATION													
0.64	2.48	7.95	12.81	15.70	19.38	20.43	18.21	14.12	6.20	1.09	0.66	119.67	30–31
AVERAGE MONTHLY MEAN RELATIVE HUMIDITY.													
75	70	72	76	80	85	85	86	84	81	76	76	79	16–18

DHUBRI, PROVINCE OF ASSAM.

Latitude 26° 7′ N. Longitude 89° 50′ E. Elevation 115.34 feet.

Jan.	Feb.	March	April.	May.	June	July.	Aug	Sept.	Oct	Nov.	Dec.	Annual.	Length of Record. Years.
NORMAL MONTHLY TEMPERATURE—DEGREES F.													
62.6	64.8	74.9	78.3	78.5	80.0	82.2	81.1	79.9	78.2	70.9	64.5	74.7	6–7
NORMAL MONTHLY PRECIPITATION.													
0.32	0.50	2.04	5.21	15.96	26.75	14.90	11.80	12.42	4.17	0.02	0.19	94.28	16–18
AVERAGE MONTHLY MEAN RELATIVE HUMIDITY.													
77	64	61	68	80	87	85	86	87	81	76	77	77	6–7

TURA, PROVINCE OF ASSAM.

Latitude 25° 30′ N. Longitude 90° 17′ E. Elevation ____ feet.

Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	Length of Record. Years.
NORMAL MONTHLY TEMPERATURE—DEGREES F.													
61.3	63.4	74.5	77.9	76.0	-------	78.0	77.3	77.2	74.5	68.6	6.30	-------	3–4
NORMAL MONTHLY PRECIPITATION.													
0.60	0.83	1.97	5.77	15.93	24.71	23.50	20.75	20.54	7.85	0.39	0.14	122.98	17–18

X.—Sketch of the Physical Geography and Climate of North Carolina.

The topography of North Carolina is strikingly diversified. The State lies between the parallels of 33 degrees 50 and 36 degrees 33 north latitude, and between 75 degrees 27 and 84 degrees 42 west longitude, and extends from the Atlantic Ocean on the east to the crest of the Smoky Mountains on the west. The extreme length of the State is 503 miles, its breadth 189 miles, and it occupies an area of 52,286 square miles, of which 3,600 square miles are water surface.

The State is naturally divided into three climatic regions. These divisions are called the Eastern, the Central and the Western Districts. In this subdivision the greater part of the Piedmont section is included with the Western District, as climatically nearer allied to the mountainous than to the central level portions of the State. The Eastern District embraces 36 counties, the Central 26, and the Western 34, each representing nearly one-third the area of the State.

Eastern District.

The Eastern District embraces that portion of the State extending about 100 miles westward from the coast, and includes the lower, or navigable portions of the larger rivers of the State. The drainage is towards the southeast; the land is nearly level, rising gradually to an elevation of about 250 feet in the western portion. To this district belong all the counties touching the sea, and it contains within its area all the swamp lands, lakes, sounds and bays of the State, besides numerous but generally small islands.

Central District.

The Central District includes the middle portion of the State from the western limit of the Eastern District to the Yadkin River. The topography of the surface of the country begins to change; it is no longer entirely level, but rolling, and in the western portion hills and valleys appear. The elevation varies from 250 feet on the east to 800 feet in the northwest portion. The drainage of the greater part is towards the south, but in the northern tier of counties the streams flow northward into the Dan, which, in its lower course, takes the name Roanoke River. The watershed between these two drainage areas is the broad ridge, having an elevation of nearly 800 feet, which extends eastward from the Blue Ridge through Stokes, Rockingham, Caswell and Person counties, terminating in the latter in the heights called Hagas Mountains, which attain an elevation of 1,000 feet.

Western District.

The Western District embraces all that portion of the State west of the Yadkin River, except the three counties of Stanly, Union and Anson. The portion east of the Blue Ridge is the Piedmont section. It has an average elevation of 1,000 feet, and is distinctly a region of mountains and valleys. The drainage takes place through the Yadkin, Catawba and Broad, the first two flowing towards the east and northeast, then making sharp bends to the south, the latter flowing directly south, all reaching the Atlantic Ocean through South Carolina. The upper basins of these three rivers are separated by mountain chains trending eastward from the Blue Ridge.

The climate of the State is fixed by its location in middle latitudes, and by its relative position to the general course of low areas or cyclonic storms in the United States. Situated between the parallels of 34 and 37 degrees north, the average climate of the whole State is strictly that of the warm temperate zone, modified by various causes. The modifying influences are the proximity of the ocean on the east, the general topography of the State, the configuration of the surface, the nature and covering of the soil, the drainage areas, and especially the mountain system in the west, which gives North Carolina a greater diversity in climatic features than any other region of similar area possesses. The eastern margin, which is thrust forward into the Atlantic, considerably beyond what would be normal trend of the coast line, has distinctly an insular or marine climate, that is characterized by uniformity, with small ranges in temperature, both diurnal and seasonal, and abundant precipitation. Towards the interior the influence of the ocean diminishes, the extremes of temperature are greater, the rainfall less; while in the western or mountainous section the effect of elevation predominates, giving cooler summers and a salubrious atmosphere.

The Gulf Stream, as a source of abundant heat and moisture, may well modify the course of sub-tropical cyclones, which, originating in the West Indies, travel northwest, and recurving about the parallel of 30 degrees north, move thence northeast along the Atlantic coast influencing for a few days the weather of this region.

MONTHLY, ANNUAL AND SEASONAL MEAN TEMPERATURES FOR THE DIFFERENT DISTRICTS AND FOR THE STATE.—DEGREES F.

	Jan.	Feb	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Eastern District	43.6	46.0	49.5	57.8	67.4	75.1	78.8	77.2	72.3	62.4	52.7	45.2	60.7
Central District	40.7	44.2	49.2	59.8	68.2	75.7	78.7	76.0	69.8	59.2	49.1	43.2	59.5
Western District	38.5	41.8	46.0	56.3	64.1	70.9	74.4	72.2	66.2	55.3	45.6	39.8	55.9
State	40.8	44.3	48.0	57.7	66.9	74.4	77.8	75.8	70.2	59.7	49.7	42.7	59.0

	Spring.	Summer.	Autumn.	Winter.
Eastern District	58.2	77.0	62.5	44.9
Central District	59.1	76.8	59.4	42.7
Western District	55.5	72.5	55.7	40.0
For the State	57.5	76.0	59.5	42.6

The true mean temperature of North Carolina is 59.0 degrees F., which is the normal for twenty years. This is within half a degree of the calculated mean temperature of the northern hemisphere, which is 59.5 degrees, according to Ferrel. It will be noted that the mean temperature of the Central District corresponds very closely with the means for the State, and especially with the spring and autumn means. Autumn is much warmer than spring in the Eastern District, while they are about the same in the rest of the State. The increase of temperature is most rapid from March to April -|- 9.7 degrees, and from April to May, -|- 9.2 degrees; the most rapid decrease occurs from September to October, —10.5 degrees, and from October to November, —10.0 degrees. The coldest month is January, the warmest is July.

The average date of the first killing frost in North Carolina is October 10th, but light frosts occur early in September; the last killing frosts of spring occur most frequently in April, though some severe frosts have been recorded in May. The first killing frosts during the past few years have occurred on the following dates: 1888, September 30th; 1889, October 7th; 1890, October 28; 1891, October 9th. The last killing frosts of spring occurred in 1888, on May 15th; 1889, May 4th; 1890, April 21st, and in 1891, on May 8th.

The formation of ice to any considerable thickness is extremely rare.

The annual precipitation varies from 40 to over 70 inches, the average for the entire State being 53.29 inches, which is the normal for twenty years. North Carolina, therefore, belongs to the region of the United States which is characterized by the largest precipitation, the center of which is the Gulf coast, about the mouth of the Mississippi.

The averages for the different districts and seasons are as follows in inches:

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Eastern District	4.60	3.48	4.64	4.20	4.01	4.40	5.98	6.66	5.64	4.04	3.42	4.16	55.23
Central District	4.30	4.25	4.21	3.75	4.27	4.00	4.66	5.33	4.30	3.47	3.53	3 73	49.85
Western District	4.75	5.40	5.56	3.75	4 38	4.34	5.19	5.42	3.88	3.38	3.35	3.92	53.32
For the State	4.52	4.25	4.90	3.84	4.20	4.34	5.44	6.09	4.65	3.66	3.40	4.00	53.29

	Spring.	Summer.	Autumn.	Winter.
Eastern District	12.85	17.04	13.10	12.24
Central District	12.18	13.99	11.35	12.28
Western District	13.69	14.95	10.61	14.07
For the State	12.94	15.87	11.71	12.77

It is evident from this table that the distribution of precipitation is quite uniform throughout the year. The largest amounts occur in July and August, at the period when vegetation requires much moisture as well as heat. The driest months are October and November, when crops are no longer materially influenced by the weather. The wettest month has an average of 6.09 inches, the driest 3.40 inches; there is, therefore, no wet or dry season in North Carolina. Periods of drought are rare and of short duration, and, of course, no such thing as an entire failure of crops from this cause has ever been known. A short dry period almost always occurs in June.

For comparison with the figures above given for North Carolina we subjoin a short table of mean annual temperatures and rain-fall for the principal European cities, and for Tokio, Japan:

City.	Mean Annual Temperature. Degrees F.	Average Annual Rainfall in Inches.
Palermo	64.2	29.92
Venice	56.3	23.62
Rome	59.5	30.32
Paris	50.5	22 84
Berlin	48.2	23.32
Tokio, Japan	56.5	73.23
Madrid	56.3	14.96
Lisbon	60.1	28.74
Naples	60.6	32.68
London	50.5	24.02

For the above sketch of climate of North Carolina we are indebted to Climatology of North Carolina, published by the North Carolina Agricultural Experiment Station in 1892.

XI.—The Chemical and Physical Properties of Silk.

Silk is composed of carbon, 50.69 per cent; oxygen, 34.04 per cent; hydrogen, 3.94 per cent; nitrogen, 11.33 per cent.

The filament as it comes from the insect is double—that is to say,

it is composed of two distinct threads laid side by side and united only by the natural gum or cement supplied by the insect. Each normal cocoon gives about 4,000 feet of filament, which has a diameter of about 1-2500 inch. One pound of this filament will measure about 1,846,590 yards. Silk is heavier than water, having a specific gravity of 1.36. The natural thread is coated with a sort of waxy gum, which forms about 23 per cent of the total weight of the thread. This gum is insoluble in cold water, but is soluble in water heated to 180 degrees F., and in dilute watery solutions of soda and potash. When freed from gum and fiber is readily dissolved by strong acids, concentrated alcohol, and ammoniacal oxide of nickel.

Silk in commerce is graded according to the following properties:

1. *Tenacity.*—This is the property by which the thread resists breaking when stretched. The tenacity of any sample depends chiefly upon the number of distinct filaments which enter into it. To facilitate comparisons silk reelers have agreed upon a standard thread of such size that 500 meters (1,640 feet) weigh just 1.62 grams (about 25 grains, Troy).

A good silk thread having a cross section of 1 square millimeter, 4-100 inch, should not break under a less strain than 95 pounds when freely suspended.

2. *Ductility.*—This is the property by which the thread stretches without breaking when pulled. Good silk should stretch 12.50 per cent of its length without breaking.

3. *Elasticity.*—This is the property by which the thread when stretched within the limits of tenacity tends to recover its former length. Good silk should, under such circumstances, recover over one-third the stretch.

4. *Hygrometricity.*—This is the property by which the thread holds water at ordinary atmospheric temperatures. Good merchantable silk should hold not more than 11.7 per cent of water at ordinary temperatures. This water can be evaporated only at about 275 degrees F.

XII.—Home-Spun Silk.

The scope of this Bulletin does not include the description of methods used in the manufacture of silk cloth. But as many small growers of silk will desire to work up their fiber, or at least the floss silk, into articles for home use, a few words on the cleansing and dyeing of silk will not be out of place here.

The natural silk thread as it comes from the reel or spinning wheel contains coloring matter, oil, gum and wax. About 23 per cent of the gross weight of silk consists of these matters. Most of these substances must be removed from the fiber before it can be dyed. The gum and wax are soluble in boiling water and in weak alkaline solu-

tions—3 per cent sodium corbonate. Glossy or "brilliant" silks retain a part of their natural gum and wax, whereas "dull" silks have these substances entirely removed. It is considered undesirable to remove all of the natural gums, hence prolonged boiling, and heating to high temperatures are considered injurious to silks.

The water used in degumming silk must be of the softest kind and free from grit and sediment. No more water than is absolutely necessary should be used. Experience has shown that one gallon of water and two and one-half ounces of soap are sufficient to cleanse one pound of silk thread or yarn. One hour's simmering just below the boiling temperature should effect a thorough cleansing. The water should be first heated to boiling point and then cooled with a little cold water before the silk is added. Turn and stir the silk frequently. Before putting the silk to simmer tie several skeins into a hank, and the hanks of the same class and quality of silk into separate bundles of convenient size. Great care should be exercised in grading the silks in order to ensure uniform results. Tie the bundles to a brass—not iron—wire hoop and sink in a brass, or copper, or porcelain-lined kettle or vat. When the silk becomes white and soft, or free from gum, remove from first bath, wring, straighten the skeins and roll up in a coarse linen sack. Place sack in a fresh clean bath similar to the first and again simmer for one-fourth hour, stirring constantly. After second bath remove, rinse in clear water and wring out as before.

Silk thread for sewing, knitting and similar home uses is usually made from floss silk, which is combed and spun on a wheel in exactly the same way as linen thread. The silk thread, after being spun, is cleansed as above described and is ready for dyeing.

Dyeing Silk.

Silk takes and holds colors better than cotton or linen, but less so than wool. A mordant is always necessary. Alum is the one most used. It must be of the best quality and free from iron. The following recipes are from a standard German work on dyeing and are reliable. The quantities of the different substances prescribed are calculated in each case for 10 pounds of cleansed and dried silk thread:

1.—A Citron Yellow.

Dissolve 1¼ pounds alum in 20 gallons boiling water. In this soak the silk one-half hour, constantly stirring and beating; wring it out, and throw away the alum water. In same kettle boil for one-half hour in 20 gallons water 8 pounds safflower, ¼pound alum; strain and run into a tub. In this soak the silk for one-half hour, stirring and beating constantly; wring, rinse and dry.

2.—Orange Yellow.

To the safflower, both above described (Formula, No. 1), add 2 or 3 ounces of soda carbonate and same quantity of annato. But first steep the silk a few minutes in the simple solution of safflower (Formula, No. 1.)

3.—A Buff Yellow.

For the amount of safflower used in No. 1 substitute 40 pounds turmeric, and proceed as in Formula, No. 1.

4.—A Pink.

Tie 15 pounds safflower in a coarse sack and immerse in running water until the yellow color is all washed out. Dissolve 2 pounds carbonate of potash in 4 gallons water and pour over the leached safflower in a clean tub. Let stand six hours; strain, add 3 ounces vinegar and 3-8 ounce sulphuric acid. In this bath, soak the thread 4 hours with frequent stirring and beating. Wring it out, rinse in running water and dry.

Dissolve 4 ounces cream of tartar in 10 gallons of water. In this steep the silk for three-fourths hour with constant beating; wring and dry.

5. A Bright Crimson.

Dissolve 2½ pounds Roman alum in 20 gallons water; strain. In this steep and beat the silk 4 hours. Rinse and wring dry.

In 16 gallons water boil for 10 minutes: 1¼ pound cochineal, 1 pound powdered nut-galls, ¼ pound cream of tartar; strain, and in this steep the silk, with frequent beating, for 1 hour. Rinse, wring and dry.

In this recipe 3 pounds cudbear may be substituted for one-half the annato, but the color will be less desirable.

6.—A Fine Nankeen.

(1) In 16 gallons water boil for 10 minutes 2 pounds powdered nut-galls; strain.

(2) In one-half gallon of water boil till dissolved one-half pound soap.

(3) Mix (1) and (2).

(4) In 2 gallons water boil 15 or 20 minutes 1 ounce annato, 4 ounces carbonate of potash; strain.

(5) Add one-half of (4) to (3).

In (5) steep the silk one-fourth hour with frequent beating. If color is not deep enough add more of (4). Remove, rinse quickly and dry.

7.—A Medium Blue.

(1) In 20 gallons water boil 10 pounds sulphate of iron.

(2) In 5 gallons water boil 10 pounds soap.

(3) In 20 gallons water boil 12 ounces prussiate of potash, and make it weakly acid with muriatic acid. Steep the silk in (1) for one-half hour. Rinse, wring and without drying steep in (2), kept just below boiling temperature, for one-half hour. Rinse and steep in (3) one-fourth to one-half hour. Rinse and dry.

8.—A Deep Blue.

For a very deep blue before steeping in (2), Formula 7, steep the silk one-fourth to one-half hour in a bath of one-half to one pound cochineal in 10 gallons water. Then proceed as in Formula 7.

9.—Green.

(1) In 100 gallons water dissolve Indigo, 5 pounds; copperas, 5 pounds; lime, 15 pounds. Strain.

(2) In 15 gallons water dissolve 2 pounds alum.

(3) In 20 gallons water boil for three-fourths hour 4 pounds quercitron. Strain. Add 8 ounces sulphuric acid. Steep the silk in (1) until it shows a light blue color. Rinse and wring dry.

Steep in (2) 2 hours; wring dry.

Steep in (3) until the desired shade of green is obtained.

Turmeric in varying quantities added to (3) will give different shades of green.

10.—Black.

Cleanse the silk thoroughly in soap and water. Steep until bleached in a solution of 1 pound sulphurous acid in 25 gallons of water. Rinse, dry and return to a fresh soap bath.

(1) In 10 gallons of water boil for one-fourth hour 7 pounds powdered nut-galls. In this boil the soaped silk one-fourth hour; remove from fire and let it steep for 36 hours longer. Rinse and wring.

(2) In 20 gallons of water, just below boiling temperature, dissolve 4 pounds sulphate of iron and 1½ pounds gum arabic. Simmer, but not boil, the silk in this for 1 hour. Remove from fire and let steep 12 hours. Rinse and wash in warm soapy water. Rinse and dry.

Note.—For cuts Nos. 7 to [illegible] used in this Bulletin, we are under obligation to the U. S. Department of Agriculture. Cut No. 5, supplied by Thos. Mehan & Son, of Philadelphia. Cut No. 15, by Bausch & Lomb Co., of Rochester, N. Y. The others were redrawn from various sources. In the preparation of the text we have drawn freely from standard Italian and French treatises, but are more especially indebted to the publications of the Chevalier Dr. E. Quajat, of the Royal Italian Silk Experiment Station at Padua.